Charles University
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Study Program: Finance, Financial Markets and Banking

Cheating Behavior in Football

Master Thesis

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May 2014

Abstract

In this thesis I provide statistical evidence documenting rigging of football matches in German long-term championship Bundesliga. For the purpose I use 8326 matches played in top three German long-term competitions through years 1995 – 2012. The championship is based on a point collection in a standings table divided by strict success margins, e.g. title or relegation. The margins lead to a non-linear incentive structure in which one point is worth more for teams close to the margin. Uncertainty about the final outcome, however, postpones the equilibrating effect to the last rounds of a season. I find evidence of increased point earnings as a reaction on relegation margin closeness at the end of a season. Increased effort of the marginal teams cannot explain the findings as players exert no better performance in the incentive situation. In the same time, their opponents with long margin distance decrease their performance. In addition to that I provide evidence on cheating cooperation proxied by variance of players' performance. The variance does not react on the incentive situation suggesting that teammates behave unitedly. Performance of referees seems to exert stable performance with no reaction on teams' incentives. Overall, the results show strong evidence of systemic point trading in German Bundesliga.

Keywords: Cheating optimization, football, match rigging, incentive.
JEL-Classification: D22, D61, K42, L83, M52.

Abstrakt

V diplomovej práci dokumentujem manipulovanie futbalových stretnutí v Bundeslige, nemeckej dlhodobej súťaži. Používam 8326 zápasov z troch najvyšších nemeckých súťaží za roky 1995 – 2012. Ligová súťaž je založená na zbieraní bodov do tabuľky, ktorá je následne rozdelená ostrými hranicami úspechu – napríklad titul, alebo boj o udržanie sa v lige. Ostré hranice vedú k nelineárnej štruktúre, v ktorej má bod väčšiu hodnotu pre tímy blízko k najbližšej hranici. Neistota ohľadom konečného výsledku však posunie vyrovnávací efekt do posledných kôl sezóny. Na základe dát ukazujem zvýšenie počtu získaných bodov pri tímoch, ktoré sú na konci sezóny blízko hranice zostupu. Tento výsledok nie je však podporený ich zlepšeným výkonom. Naviac, v rovnakej situácii podávajú ich oponenti s vysokou vzdialenosťou k najbližšej hranici zhoršené výkony. Výsledky podporujem analýzou kooperácie hráčov, k čomu využívam rozptyl ich výkonov. Výsledky nepreukazujú žiadnu reakciu, čo naznačuje, že hráči konajú v rámci tímu jednotne. Analýza rozhodcov nepreukázala žiadnu reakciu na zvýšené podnety tímov a rozhodcovia preukazujú stabilné výkony. Predložené výsledky poskytujú silný základ pre tvrdenie o systematickom obchodovaní s bodmi v nemeckej futbalovej lige.

Kľúčové slová: Optimalizácia podvádzania, futbal, manipulovanie zápasov, podnet.
Klasifikácia JEL: D22, D61, K42, L83, M52

Declaration

I declare on my honor that I wrote this master thesis independently, and I used no other sources and aids than those indicated.

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Prague, 15 May 2014

I would like to thank my supervisor Michal Bauer, Ph.D. for his patience, great comments and advises. Special thanks goes to Ing. Petr Houdek for his challenging insights and discussions. Thank belongs also to Bc. Marek Pažitka for his comments in the early stages of the thesis. Last but not least I would like to thank my mother and father for supporting me in my studies and also Zuzka, Zuzanka, Dorotka and Karol for giving me my second home in Prague.

They all have plenty of points and we have nothing.
Jesus, we are not going to be relegated, are we?

Passage from Ivánku, kamaráde, můžeš mluvit?
by Petr Čtvrtníček.

Contents

1 Introduction

The amount of work building on Gary Becker's economic perspective (Becker, 1993) has been increasing since the first read. Looking at people's behavior as a comparison of benefits and costs allows us to bring economics to basically every area of man's life. Likewise, cheating and corruption have fascinated economists for a long time and the field of forensic economics has become a raising phenomenon (Zitzewitz, 2012b). The fascination comes from a wide acceptation of cheating and corruption as a welfare decreasing behavior with a negative impact on economic efficiency. For example, works of Becker and Stigler (1974) and Aidt (2003) are trying to set rules such that they avoid cheating.

Covering tracks is the property that connects every cheating behavior and makes its studying difficult from definition. Publicly available sport statistics are an exception in an environment where lack of data became a standard. Taking every sportsman or a sport team as a profit maximizer who weights costs and benefits allows me to uncover various incentive settings. As a result, every setting has different optimal cheating level.

In many countries have fans witnessed huge sport corruption scandals. The biggest scandal witnessed Italian fans in 2006. Several top clubs, including Juventus Turin, AC Milan or Lazio Roma, were found guilty of match manipulation (BBC, 2006). Italians are, however, not alone and scandals erupted also in Czech Republic (ČTK, 2010), Slovakia (SITA, 2013), Portugal (Vernet-Riera, 2010) or Germany (Bild, 2005).

In this thesis I study cheating behavior of teams in Bundesliga, German long-term football championship. Instead of concentrating on individual cases I follow the works that explore general patterns resulting from incentive reaction, e.g. Duggan and Levitt (2002); Wolfers (2006) or Zitzewitz (2006). The cheating-revealing mechanism used in this thesis is mostly inspirited by Duggan and Levitt (2002). Unlike the cited study I cannot use discontinuous jump in incentives and I use gradual shift during a season instead.

After a season starts, teams form a standings table summarizing earned points, scored goals and several other statistics. The table can be then divided into 3 parts – winners at the top, the ones in the middle and survivors at the bottom of the table. Teams at the extremes are close to the "success margins", i.e. title for winners and survival for the ones at the bottom. Teams in the middle are, in contrast, far from both margins and both marginal revenues of earning a point and marginal cost of losing one are low. At the end of a season, teams get rid of most of the season's uncertainty and many of them already know for sure if they will reach one of the margins. It does not matter if team survives in a league only by a better score or with a point bonus. It can be therefore profitable for teams to earn as many points as possible and then sell the surplus at the end of a season to the teams who need it more.

Teams from the extremes demand cheating, while suppliers are the ones from the table's middle. Top teams should on average beat both teams in the middle and the ones at the bottom. On the other hand, teams from the bottom should on average lose. Therefore, top teams will *not* propose cheating, which will be demanded only by teams from the bottom part. Changed frequency of winning can, however, be also caused by a higher motivation of teams at the bottom, together with a lower motivation of teams in the middle. To distinguish the cheating and change in motivation I analyze also players' and referees' performance. Better results of a bottom-team caused by a change in motivation must be accompanied by their higher performance. In contrast, better results without a support of increased performance are suspicious especially when the opponent decreases its performance in reaction on incentive. Similarly, decreased performance of referees in suspicious matches is a signal of their possible involvement in cheating.

The results show that last rounds of a season are accompanied by a significant increase in earned points of teams at the bottom of the standings table. In a simplified form can the explanation lie either in an increased effort of players or in teams' cooperation (rigging). In this thesis I offer several tests to push the explanation either to a higher effort or to a match rigging. I collect data on players' and referees' performance thanks to which I am able to monitor their performance. All the data I take from the website of respected German sport magazine *Kicker*. The magazine collects not only results, but also match statistics accompanied by editor's subjective evaluation of referee's and players' performance.

In an ideal world is referees' performance stable. The opposite points to their involvement in cheating. On the other hand, players' performance should be higher when their team earns more points. If the situation does not occur, the point earnings must come from a different source – cheating. Referees appear to perform rather stable no matter of the incentives in which teams play. In contrast, players react greatly on changing incentives. In general, players – in line with the assumptions – play better at the end of season. However, players of teams fighting for a league survival perform *equally or worse* while earning *more* points. In the same time, opponent of the "incentivized" team plays worse. The fact strongly suggests deceitful behavior and cooperation of players on the final result.

This thesis contributes to a current knowledge in several aspects. Firstly, it sheds more light into the optimization of cheating behavior, possibly generalizable also to business outside the sport industry. Secondly, the results can improve valuation models of betting agencies allowing them to better estimate chances of match outcomes. Thirdly, the results are utilizable also by fans who can better estimate attractiveness of the match and, as a result equalize the incentives during a season. Income from tickets plays a crucial role in club's budget. Clubs are therefore afraid of a lower visit rate, which increases costs of cheating. Having this in mind, the result can be a smaller shift in incentives and therefore less cheating. In the same time, the research is done in one of the least corrupted environments in the world (T.I., 2012), making the results to set rather lower bound of cheating.

The rest of the thesis is organized as follows. In the second part I develop theoretical background divided to literature overview and a formal model. Section 3 describes the collected data together with summary statistics. Section 4 develops empirical models in an attempt to reveal incentive reaction of point earnings, referee and player performance. Section 5 shows the results of the empirical model and offers their interpretation. Finally, section 6 concludes with a discussion of the implications and possible future research enhancement.

2 Theoretical Background

2.1 Literature overview

Although cheating and corruption is widely-discussed phenomenon, missing data are rather limiting for empirical research. Lack of data comes from the very nature of corruption where everybody engaged in the behavior tries to hide it. Many studies are therefore based on a statistical analysis of general patterns hidden in data. Standing on the idea, whole new research field of forensic economics has emerged.

As Zitzewitz (2012b) claims, forensic economics involves many areas for research such as finance, labor, public and educational economics. Heron and Lie (2007) use a change in option backdating regulation to find if diminished ability to alter the strike price results in lower abnormal negative stock performance before executive option grants and abnormal positive return after the execution. Using the data on option grants to CEOs, authors show that abnormal returns are more typical for the period of weaker regulation. As authors report, the magnitude of abnormal return before the grant is approximately 6 times larger for the weaker-regulation period than for the stronger one.

Another study comes from Chicago public elementary schools where Jacob and Levitt (2003) study cheating of teachers. Authors detect unexpected test score fluctuations and suspicious patterns of answers in a classroom. As a result they are able to detect teacher's cheating in a minimum of 4-5% of classes.

Great amount of data is offered also by sport statistics. In recent time are the statistics increasingly used in forensic economic analysis. Wolfers (2006) examines the gambling-related corruption called "point shaving". The mechanism is based on a spread given on widely expected win. In other words, the bet is winning only if team wins by more than stated number of points (or goals). As author claims, the idea lies in asymmetric incentives for players who care about winning a game and gamblers who care about the spread. Author finds indicative evidence that about 6% of strong favorites are willing to sell the game by manipulating the spread. Similar conclusions were found by Gibbs (2007) who uses the same methodology, but instead of applying it on university-level basketball, he uses a professional NBA data. The results are, however, challenged by studies of Paul and Weinbach (2011) and Heston and Bernhardt (2008). First study found alternative results to Wolfers (2006). Running several tests ranging from point spread to coach analysis, they find only a little evidence to support Wolfer's results. Heston and Bernhardt (2008) explore the source of patterns explained by point shaving. Authors report strategic movements as a better explanation as they, for example, find similar patterns also on games without betting.

Another methodology uses Zitzewitz (2006) who studies nationalism in judges evaluation in ski jumping and figure skating. While ski jumping judges compensate for nationalistic biases of other members, figure skating engage in vote trading and bloc judging. In ski jumping, the internationally-picked referees compensate for nationalism, which is consistent with the desire of fairness. In contrast, positive compensating biases of nationally-picked referees in figure skating seems to be consistent more with vote trading or reciprocity. Another author's study shows, using the same methodology, that anti-referee-bias reforms adopted after 1998 and 2002 Olympics have not decreased the bias. On the contrary, the after-reform bias has slightly increased (Zitzewitz, 2012a).

Corruption in football is estimated by (Reade and Akie, 2013) who use the difference between predictions of bookmakers and those constructed by models. Authors argue that both estimates use the same data and thus should predict same results. Any divergence of the two points to a corruption, which is mildly discovered in the study. Other papers studying the biases in football are more centered around social pressure as the cause. Rocha et al. (2013) evaluates the home bias of referees. Brazilian referees systematically set more time if home team is closely behind. Similarly, other papers positively test for home bias when applying the card punishment (Pettersson-Lidbom and Priks, 2010; Reilly and Witt, 2013), or penalty (Dohmen, 2008).

Probably the most famous example comes from Duggan and Levitt (2002) who analyzed corruption in professional sumo wrestling. The mechanism is based on a simple idea that wrestlers get non-linear number of points for winning, important for wrestler's rank. Playing a tournament, each wrestler's payoff rises linearly after winning matches 1-7 and 9-10. However, 8^{th} match is special in earning almost four times as many points as for the other matches. Because the quality of players remains unchanged, the probability of winning the 8^{th} should be in theory the same as for the rest ones. In contrast to the theoretical distribution, wrestler fighting on the 8^{th} match wins more often than predicted. In other words, wrestlers win more often when they can get more points for the same win. To distinguish between higher exerted effort of the 8^{th}-match wrestlers and actual cheating authors push the answer to the latter one as e.g. 8^{th}-match winners loose too often in the next match.

Last methodology is the most important for this thesis due to its similarity in two areas. Firstly, it exploits similar algorithm as the one used in Duggan and Levitt (2002). Unlike cited algorithm, I cannot use strict jump in incentives. Instead I use gradual increase of incentives to cheat for a particular group of teams. Secondly, both studies are done in low-level cheating environments. Japan and Germany are considered as one of the least corrupted countries in the world (T.I., 2012).[1] As suggests Fisman and Miguel (2006), country-level cultural norms translate also to real-world situations. I expect similar mechanism to hold also for football environment.

Unlike sumo wrestling or any other individual sport, football is a collective sport making it even more difficult to cheat. If a wrestler decides to cheat, only one individual is needed to achieve the goal. On the other hand, one individual in collective sports has lower ability to influence the outcome. Therefore, higher difficulty to cheat makes football less prone to cheating than, e.g. sumo wrestling.

[1]According to Corruption Perception Index 2012 is Germany on 13^{th} place with 79 points (out of 100) and Japan occupies 17^{th} position with 74 points respectively.

2.2 Theoretical model

In this section I examine the incentives of both teams to rig a match. Building on Duggan and Levitt (2002) I derive a model, which deals with an idea of changed weighted revenues during a season, leaving the probability of future cooperation constant. Unlike sumo wrestling in their study, football does not offer discontinuous jump in incentives. For the reason I build my model on gradual whole-season change in incentives.

The model makes following assumptions:

1. I consider team as one risk-neutral utility maximizer.

2. Both opponents and dates when they are challenged are known at the beginning of season.

3. In a not-rigged match, both teams expect their chances to win the match based on the quality of their and opponent's team.

4. Teams have at least twice-differentiable utility function *U(x)* for which $\frac{\mathrm{d}}{\mathrm{d}x}(U(x)) > 0$ and $\frac{\mathrm{d}^2}{\mathrm{d}x^2}(U(x)) < 0$, where x denotes the distance from the closer margin.

5. Revenues of cheating are dependent on the stage of season.

6. When two teams agree to rig a match, a transfer is made from proposing team i to receiving team j.

7. The magnitude of the transfer is determined by teams' bargaining. Team i proposes a one-time, take-it-or-leave-it offer to the team j in exchange for intentionally losing the game.

8. Teams play for a closer margin, i.e. for the margin that has the lowest difference between team's actual earned points and the points needed to reach the margin.

Firstly, I assume that decisions are taken by one "chief" and not by a vote. I take the assumption in order to not deal with voting procedures inside the team. Moreover, there is no significant reason to think that average "chief" will be different from average voting outcome.

The necessity to know all opponents and the date of match in advance is important for team to make predictions about their probability to achieve desired goal. Similarly, team must know all the estimates of opponents' quality to form expectations about future outcomes. Every team uses *Poisson binomial distribution*[2] to estimate its probability to reach a desired margin (Wang, 1993):

$$\Pi_t(k, \boldsymbol{\pi}) = \sum_{A \in F_k} \Big(\prod_{i \in A} \pi_t \Big) \Big(\prod_{s \in A^c} (1 - \pi_s) \Big) \tag{1}$$

where Π_t is the probability of reaching a margin in a given time (round), k is the number of matches needed to win in order to reach the desired margin and $\boldsymbol{\pi}$ is a vector of probabilities of winning a match at time t. F_k is the number of subsets of size k out of n, i.e. the number of possible combinations to reach a margin. First bracket represents the sequence of probabilities of the success of team i in round t. Second bracket represents the sequence of probabilities of failure of team i in all but the t^{th} round.[3] Team in each round t evaluates its probability Π_t to reach a margin. After each round then team compares potential revenues from cheating with its costs. Team will try to rig a match if (and only if) revenues from cheating are higher or equal to its costs.

The decision making about costs can be decomposed to its absolute amount and the probability of being caught. The absolute amount is composed of direct costs like monetary penalty and points deduction together with implicit costs like loss of reputation and loss of revenues from marketing and selling tickets. Team weights above-mentioned costs by estimated

[2]For the sake of simplicity I assume that the match's outcome is binomial – either win or loss. Adding a draw would lead to a multinomial model, while little value would be added to the model.

[3]I choose Poisson binomial distribution for the possibility to use different probabilities in each round. The character of the championship when team faces in each round opponent with different quality limits the use of simpler binomial distribution. Poisson bivariate distribution is, however, only a generalization of binomial distribution; letting p_t to be constant over time reduces the equation to $\Pi_t(k) = \binom{n}{k} \pi^k (1-\pi)^{n-k}$.

probability of being caught. Until some exogenous shock occurs there is no reason to believe that either these costs or the probability change throughout a season.

Except potential costs when the cheating is discovered, team considers also sure costs of bribing either opponent or referee (or both).[4] The amount for which are receivers (opponent or referee) willing to cheat is subject to a bargaining process and can be thus dependent on the stage of a season. If the receiver knows that proposing team strongly needs to earn points to reach a goal, it will set price high and vice versa. Because all relevant information is publicly available, the price charged will positively follow the number of already played rounds. On the other hand, most of the teams stay in a league for many seasons and thus compete with each other regularly. There is thus probability with which they will change their roles, i.e. receiving team becomes proposer and proposing team becomes receiver. Having the probability of meeting each other high, receiving team "invests" in the proposing team and charges less than it otherwise would causing the stability of the "bribe". As is stated in the assumptions, for the sake of simplicity I further consider one-time take-it-or-leave-it offer by team i. Moreover, later I show that theoretically I cannot distinguish between two approaches, because the investment pushes the price to be less variable.

Despite the fact that team can earn 3 point for a win and 1 point for a draw in any stage of a season, in the season's latter stages has team more information about its situation in the table. At the beginning of a season, considering the quality of all teams, every team estimates its chances to win a title. Except known factors like quality of players, support from fans and financial stability is season's outcome influenced also by uncertain factors like team's crisis or injuries.

Let's divide the season into two periods, first and second. If the team is

[4]Real-world evidence shows several examples of match-rigging. In November 2013 British newspapers informed about the arrest of betting syndicate members, including "at least three footballers" (Newell, 2013). Juventus Turin has been relegated to Seria B, Italian second league, after the discovery of its match-rigging. Other three top teams of Seria A, A.C. Milan, Fiorentina and Lazio Roma, were deducted points (BBC, 2006). Overall, match-rigging is rather widespread involving spectrum of people from players to referees (Gibson, 2013).

at the bottom of the table in the first period, it has a pretty good chance that it will do better in the second period and thus not descend to a lower league. The same holds for the opposite case when team performs well in the first period, but plays poorly in the second. Bribing in the first period is thus an ineffective way of cheating, because the probability that team is close to a margin is closer either 0 or 1 in the second period.

Hypothesis: Margin teams from the table's bottom beat the non-margin ones more often than predicted at the end of a season.

Imagine team competing for a title which is 3 points behind the season's goal, i.e. is 3 points behind the *margin*. Similar situation holds for the opposite side of the table when teams compete for survival in a league. All margins are strict, there is no sharing of revenues or costs. On the other hand, teams far from the closest margin care less if they finish one rank up or down.[5]

The existence of a strict margin implies that for teams close to one is every point worth more than for teams in the middle of the standings table. The relationship is stronger with approaching end of a season. Therefore, contrary to strictness of the margin, the price of one point rises with the closeness of the margin and stage of the season.

$$margin\ dist_i = \min\{|points_i^{title} - points_i^{actual}|, |points_i^{actual} - points_i^{down}|\} \tag{2}$$

There are, however, many reasons why an opponent may be unwilling to rig a match. Except moral reasons can opponent compete for a title or he is trying to avoid relegation margin. In this case will the team compete for points in a particular match. If both teams are competing for one of the margins, they will try to get as many points as possible given their possibilities. Mathematically can be the relationship stated as follows, such

[5]Complication arises with European international cups when not only the league winner qualifies, but also several other teams. European cups thus create another margins to be considered. For a simplicity I will not consider them in theoretical model and analyze them further in an empirical one.

that both point and distance measures are higher than zero:

$$result_{ij} = \frac{\sum_{\theta}^{t} Points_i}{\sum_{\theta}^{t} Points_j} \times \frac{margin\ distance_j}{margin\ distance_i} + \varepsilon \tag{3}$$

As the name already suggests, $result_{ij}$ explains expected result of the match, having values with mean equal to 1. Expected result higher than 1 suggests win of team i, less than 1 suggests win of team j and equal to 1 predicts a draw. First ratio explains the qualitative difference between the teams, using number of points earned during period $t - \theta$ as a proxy.[6] The ratio takes expected value 1. The more points team i historically earned comparing to team j, the higher is i's comparative quality and the higher is the ratio. Second ratio explains relative motivation of teams represented by the distance to closer margin. Similarly to the first ratio is expected value equal to 1. To express similarity I use $1/margin\ distance$. The ratio has now similar behavior as the first one. Random influences on a particular match are expressed by ε. Under random influence one can imagine weather conditions, sudden injury of a key player etc. Despite being potentially very significant in one match, I assume ε to be normally distributed and therefore its expected value to be zero with rising number of rounds.

The probability of winning a match is always less than 1, because of the non-zero quality of the opponent team and random influences. Therefore, if team is close to the margin and every point can decide the binary outcome of reaching a margin or not, the team can ensure the winning by cheating cooperation.

The payoff of a proposing team i in a rigged match is:

$$[(\Pi_t^{rigged} - \Pi_{t-1}) \times W^{margin}]_i - P_{ij} - I_{ij} - c/2 \tag{4}$$

where (Π_t^{rigged} and Π_{t-1}) are the probabilities of reaching the margin in time t and *t-1* respectively. ($\Pi_t^{rigged} - \Pi_{t-1}$) is therefore an added probability of a rigged match comparing to round before. W_i^{margin} represents the wealth coming from reaching the margin after a season. P_{ij} is the price paid by

[6] t is the time considered and θ is any number less than t.

team i to team j for losing the match. I_{ij} is the investment of team j to team i with an expectation that it will pay the favor back in future if needed. Because of the long-term character of the championship and high persistence of teams in it, it is highly probable that teams will meet each other again. c are the shared costs of cheating.

In contrast, team i's payoff from a fair match is:

$$[(\Pi_t^{fair} - \Pi_{t-1}) \times W^{margin}]_i \tag{5}$$

Equation 5 is different from equation 4 in subtracted costs from cheating and changed probability of reaching a margin. Π_t^{rigged} differs from Π_t^{fair} by probability π_{ij} of winning the match. π_{ij} belongs to interval (0,1) and therefore it holds that:

$$[\Pi_t^{rigged} > \Pi_t^{fair}]_i \tag{6}$$

To propose a cheating to team j must team i's payoff from cheating be higher or equal than payoff from a fair match, i.e.

$$[(\Pi_t^{rigged} - \Pi_{t-1}) \times W^{margin}]_i - P_{ij} - I_{ij} - c/2 \geq [(\Pi_t^{fair} - \Pi_{t-1}) \times W^{margin}]_i \tag{7}$$

By rearranging I get

$$[\Pi_t^{rigged} - \Pi_t^{fair}]_i \times W_i^{margin} \geq P_{ij} + I_{ij} + c/2 \tag{8}$$

As is implied in equations above, team j's payoff in a rigged match is

$$[(\Pi_t^{rigged} - \Pi_{t-1}) \times W^{margin}]_j + P_{ij} + I_{ij} - c/2 \tag{9}$$

where contrary to team i's case, $[\Pi_t^{rigged} - \Pi_{t-1}]_j \leq 0$. On the other hand, its payoff in a fair match is

$$[(\Pi_t^{fair} - \Pi_{t-1}) \times W^{margin}]_j \tag{10}$$

For team j to rig a match the following equation must hold:

$$[(\Pi_t^{rigged} - \Pi_{t-1}) \times W^{margin}]_j + P_{ij} + I_{ij} - c/2 \geq [(\Pi_t^{fair} - \Pi_{t-1}) \times W^{margin}]_j \quad (11)$$

By rearranging I get

$$[\Pi_t^{rigged} - \Pi_t^{fair}]_j \times W_j^{margin} \geq -P_{ij} - I_{ij} + c/2 \quad (12)$$

Similarly as in team i's case, $[\Pi_t^{rigged}]_j$ differs from $[\Pi_t^{fair}]_j$ only in probability of winning a match $(1-\pi_{ij})$. The higher is the probability $(1-\pi_{ij})$, the higher is the outcome $[\Pi_t^{fair}]_j$ and therefore the less profitable is the cheating. Because $(1-\pi_{ij})$ belongs to interval (0,1), contrary to i's case it must hold that $[\Pi_t^{rigged} \leq \Pi_t^{fair}]_i$. Therefore, $[\Pi_t^{rigged} - \Pi_t^{fair}]_j$ is negative.

By assumption, team i offers a one-time take-it-or-leave-it offer to team j and has thus all the offering power.[7] Team i therefore offers exactly the amount to make team j indifferent between taking a bribe and trying to win the game with probability $(1-\pi_{ij})$. Rearranging equation 12 I get:

$$P_{ij} = -[\Pi_t^{rigged} - \Pi_t^{fair}]_j \times W_j^{margin} - I_{ij} + c/2 \quad (13)$$

The result is straightforward. Because $[\Pi_t^{rigged} - \Pi_t^{fair}]_j$ is negative, the greater is the decrease in probability of reaching the margin for team j the more is team i forced to offer. Second and third parameters hold as well; the higher is team j's welfare from reaching the margin, the more it has to be

[7]Omitting the assumption of one-time take-it-or-leave-it offer with bargaining power in proposal team's hands requires few complications. Instead of deriving P_{ij} just from receiver's equation, it is necessary to equalize both teams' equations such that they receive the same payoff: 8 and 12 I get

$$P_{ij} = \frac{W_i^{margin}}{2}[\Pi_t^{rigged} - \Pi_t^{fair}]_i - \frac{W_j^{margin}}{2}[\Pi_t^{rigged} - \Pi_t^{fair}]_j - I_{ij}$$

The equation shows that the price of certainty in winning the match is positively influenced also by i's increase in payoff. Therefore, the more can i get from rigged match (i.e. the lower is π_{ij}), the more it should pay to team j. The result is, however, negatively influenced also by I_{ji}, which has the opposite effect. The more team j decides to invest in "cheating relationship" with i, the lower is the price paid for intentionally losing a match. Because of the investment, the price is rather stable during the season. Both approaches therefore allow for bribing matches. I use the other due to its higher simplicity.

compensated for decrease in probability of reaching it. Investment of team j to "cheating relationship" with team i influences negatively the proposed price. Lastly, it depends on the transaction costs, which positively influence the price of rigging the match.

Substituting equation 13 into team i's rigging condition (equation 8) I get the more general conditions under which is team i willing to propose a cheating.

$$[\Pi_t^{rigged} - \Pi_t^{fair}]_i \times W_i^{margin} + [\Pi_t^{rigged} - \Pi_t^{fair}]_j \times W_j^{margin} - c \geq 0 \quad (14)$$

Team i is therefore more willing to propose a cheating the higher is its gain, the lower is j's loss and the lower are transaction costs. Team i's gain can be decomposed to rigged probability and the fair one. Rigged probability $[\Pi_t^{rigged}]_i$ is independent from teams' quality, while $[\Pi_t^{fair}]_i$ depends on the probability π_{ij} of winning the match against team j. Therefore, the higher is the probability π_{ij}, the lower is the incentive for team i to propose a cheating. Similarly, also team j's probability $[\Pi_t^{rigged}]_j$ is constant, while $[\Pi_t^{fair}]_j$ depends on probability $(1 - \pi_{ij})$ that j beats team i in a fair match. Therefore, the higher is the probability $(1 - \pi_{ij})$ the less likely is team j to accept an offer for a given price P (or i has to pay more). Interestingly, the investment of j into the "cheating relationship" with i does not influence i's decision whether to propose a cheating or play a fair match.

Considering equation 14, cheating is demanded by teams which are closest to the margin and supplied by teams with the furthest distance from the nearest margin. The conclusion is based on a decreasing marginal utility assumption. Team's utility is composed from welfare of reaching a margin and welfare from sold (or bought) matches. The best option for every team is therefore to earn as many points as possible and then sell matches in the final stages of a season to just reach the margin. By decreasing marginal utility, the lowest marginal utility of one additional point (or lowest marginal cost of losing a point) have teams with the longest distance from the closest margin. On the contrary, the highest marginal utility have teams competing close to a margin. Translating above-stated into real world championship, demand for cheating is created by teams at the top and bottom positions of the table, while supply is created by teams in the middle. Strong team should, however, on average beat both teams in the middle and at the bottom and it does not need to cheat. Systematic cheating of a risk-neutral team can therefore be seen only when competing for a survival. Strong team would propose cheating only if it is risk-averse and is afraid of random factors arising at the match.

3 Data

I collect data from the website of German sport magazine *Kicker*. The magazine specializes mainly on football news reporting and analysis. It performs analysis for every match played in first, second and third German Bundesliga. From the first Bundesliga I extract 5508 matches covering teams, result, goals, number of spectators and editor's evaluations of individual players and referee from season 1995/1996 to 2012/2013. Similarly, I extract 4895 matches from seasons 1997/1998 – 2012/2013 from second Bundesliga and 1900 matches from the third covering seasons 2008/2009 – 2012/2013.

Using information about point earnings – 3 points for a win, 1 point for a draw and 0 otherwise – I construct a standings table for every round. For the purpose of this thesis I am interested in teams' point standings *before* the match, the variable therefore catches the standings in the previous round.

Building on the constructed table I use information about table's division to derive margins for which teams compete and respective points needed to reach the closest one. To measure the distance I use absolute difference of actual points earned before the match and points needed to reach the margin.

$$|Cumulated\ points_{i,t-1} - Closest\ margin\ points_{i,t}| \tag{15}$$

where the closest margin is the one minimizing the distance between actual points and margins n and o. For example, if team needs 4 points to win a title and is 10 points from relegation, the team competes for a title. On the other hand, if team is 3 points behind the league survival and needs 15 points to win a title, the team competes for league survival.

$$\min |Cum.\ points - Margin_n\ points|, |Cum.\ points - Margin_o\ points| \quad (16)$$

To concentrate the distance information of both teams into one number I difference the margin distance of team j from the i's one:

$$|Cum.\ points_i - Margin\ points_i| - |Cum.\ points_j - Margin\ points_j| \quad (17)$$

Moreover, because referee is always the same for both teams, for referee-bias estimation I use symmetrical distance:

$$||Cum.\ points_i - Margin\ points_i| - |Cum.\ points_j - Margin\ points_j|| \quad (18)$$

In order to describe the differences in quality of teams I difference the points of team j from the points of team i. The variable stands on the ex-post evaluation of teams' performance. If team performs well, it regularly collects many points, while the opposite is true for less successful team. Therefore, the higher is relative quality of team i comparing to team j, the higher is value of the variable.

$$Cum.\ points_i - Cum.\ points_j \quad (19)$$

In each league teams compete for several margins. In the first Bundesliga compete teams for (1) title, (2) Champions league, (3) European league (UEFA cup), (4) relegation and in seasons 1995/1996 – 2007/2008 also Intertoto cup. Title wins always (and only) the first team bringing considerable honor and finance to the club. For both Champions league and European league competitions are set quotas by Union of European Football Association (UEFA) according to the prior results of teams from a particular league. For example, in 2004 had German Bundesliga 3 places to Champions league and another 2 to European league. In 2012 it was 4 places for Champions league and 2 for European one. Importantly, the information about the number of qualifiers is known in advance, before the season. Complications for modeling arise in deeper structure of qualification places, which have different values. For example, 3 best teams were in 2012 sent directly to the group stage of Champions league, while the fourth one was sent only to qualification with probability less than 1 to get to the main stage. The fact makes sharp margins fuzzier and *underestimates* the results. However, German teams were nominated to the last, third round of qualification and were placed to play against teams with a lower rank (from less football-successful countries). The conditions are therefore set for German teams to succeed. In case the team fails, third qualification round sends a looser to European league which makes the fall less painful. Considering all the above-stated I do *not* create another margin for individual types of Champions league and European league qualifications.

Intertoto cup is subject to similar conditions as previous two competitions except of the fact that the team has to sign-up for it before the season. After the sign-up, the team is qualified if it fails to be placed in above two European competitions and finishes at satisfactory position among signed-up teams. Intertoto cup is, however, rather insignificant summer competition of which the biggest benefit is possible qualification for European league. On the other hand, comparably high quality of German teams makes them good candidates for the tournament win. During years 2006 – 2008 were 33 teams successful in qualifying for UEFA cup (11 per season). From these teams, 3 of them were from German Bundesliga, each in one year.

Relegation is the most important margin for the purpose of this study. In all seasons of the first Bundesliga I count for 3 relegated teams per season. However, the margin is similarly to European cups rather fuzzy. For example, in season 2012/2013, 3 teams were subject to relegation, but only 2 directly while the third worst team was sent to qualification play-off against the third-best team in second Bundesliga.

The team will rather bribe an opponent in a league than in a relegation play-off. Let's suppose that team at the relegation-qualification place is considering "buying a match". The price of bribing is lower for team in the middle of the Bundesliga's standings table, because it lost the opportunity to fight for title or European cups and in the same time it is save from relegation. On the other hand, team in the relegation-qualification is one round from progression to higher-level competition. Therefore, its price for rigging a match is high causing the cheating to raise more between the league teams. Therefore, I do *not* place individual margin for relegation play-off.

For the second and third Bundesliga I count with only two possible margins – progression to a higher league or relegation. For both margins hold the same rules described for the first Bundesliga. Despite the fact that margins are not clear and for both exist also qualification, I do not consider this as significant as teams prefer bribing the league team against the qualification one.

3.1 Summary statistics

Teams in the first and second Bundesliga have to go through 34 rounds, teams in the third Bundesliga go through 38 rounds. The season is divided into two parts – autumn and spring. In the first part play all teams against each other either at home stadium or away. In the second part is home-away specification reversed to offer an equal advantage to utilize home spectators.

In first Bundesliga I use observations from season 2008/2009 to 2012/2013, which sums together 1530 observations. In case of included Intertoto cup observations I count with 5508 matches covering seasons 1995/1996 to 2012/2013.[8] Second Bundesliga covers seasons from 1997/1998 adding 4896 matches and the third Bundesliga comes from season 2008/2009 with 1900 observations.

In each round teams compete for 3 points, otherwise they get 1 point for a draw or 0 points for a loss. Building on the information I construct a standings table for each round and calculate points needed to reach the closest margin. In all rounds, teams fight for a title/advance margin 7084 times, for Champions league margin 457 times, 1002 for European league margin and 8109 for relegation margin.

To cover referee's performance I use marks assigned by editors of German

[8] If not stated otherwise, further I report only statistics of non-Intertoto matches.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
	Excluding seasons with Intertoto Cup				
Points earned in a round$_i$	1.654	1.299	0	3	8326
Points earned in a round$_j$	1.076	1.237	0	3	8326
Points in a season$_i$	22.999	15.73	0	85	8326
Points in a season$_j$	23.266	15.674	0	88	8326
Cumulated points$_{i-j}$	-0.266	10.766	-52	55	8326
Distance from margin$_i$	3.018	3.06	0	21	8326
Distance from margin$_j$	3.042	3.097	0	23	8326
Spectators	17112.06	16895.092	163	80720	7712
Sold-out	0.115	0.32	0	1	8326
Referee's mark	3.133	1.054	1	6	8017
Players' mark$_i$	3.412	0.545	1.773	5.818	8326
Players' mark$_j$	3.584	0.524	2	5.773	8326
Players' mark variance$_i$	0.47	0.242	0.021	2.173	8326
Players' mark variance$_j$	0.456	0.236	0.037	2.596	8326
	Including seasons with Intertoto Cup				
Points earned in a round$_i$	1.665	1.299	0	3	12304
Points earned in a round$_j$	0.799	1.264	-4	5	12304
Points in a season$_i$	22.801	15.632	0	85	12304
Points in a season$_j$	23.073	15.593	0	88	12304
Cumulated points$_{i-j}$	-0.272	10.802	-52	55	12304
Distance from margin$_i$	2.722	2.904	0	21	12304
Distance from margin$_j$	2.739	2.928	0	23	12304
Spectators	23126.024	18662.436	163	83000	11690
Sold-out	0.175	0.38	0	1	12304
Referee's mark	3.168	1.073	1	6	11995
Players' mark$_i$	3.439	0.55	1.773	5.818	12304
Players' mark$_j$	3.618	0.534	2	5.773	12304
Players' mark variance$_i$	0.493	0.246	0	2.173	12304
Players' mark variance$_j$	0.485	0.245	0.037	2.596	12304

Notes: All summary statistics are computed from first, second and third German Bundesliga. Data for first Bundesliga run from the season 1995/1996, for the second Bundesliga run from season 1997/1998 and for the third one run from 2008/2009 ending all in 2012/2013. Except of simple title and survival margin contains first Bundesliga also European championship, including summer competition Intertoto Cup for which teams have to sign up before the season's start. Being unable to cover the sign-ups I compute statistics with and without Intertoto observations. Presented summary statistics reflect only match-level observations. For estimation I use also inverted observations with corrected standard errors.

sport magazine Kicker. The marks range from 1 as the best mark to 6 as the worst. After the referee's evaluation has to every editor write couple of sentences describing referee's performance justifying the mark. Thanks to the openness and high rank of the magazine I take the estimates as asymptotically unbiased estimates of referee's performance.[9] 614 estimates are missing because they were not shown on the magazine's website.[10] I am not able to find any significant pattern the errors follow and I consider them as random.

Players' performance is covered similarly to referees' one. I use the evaluation of the Kicker's editors who assign marks 1 to 6 to every of the 11 players starting the match. Again, mark 1 represents the best performance and mark 6 the worst. In addition to simple mark analysis I create also variance variable. The variable covers unity of a team.

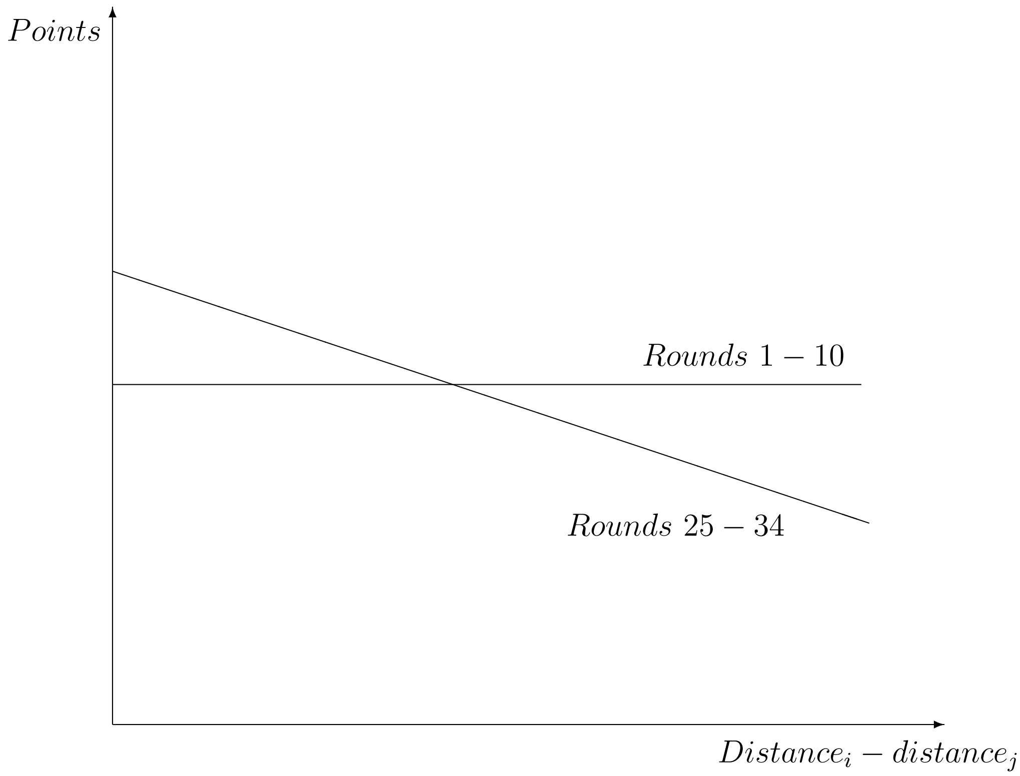
I do not have any estimates for the substitutes. However, I do not consider the fact as significant as opening eleven plays usually most of the match and has the highest impact on the match's outcome. On the other hand, problems for which I am not able to control can arise if the substitutes serve as a tool to manipulate match. For example, substitutes can be used for point-shaving rigging technique (see e.g. Diemer (2009) or Wolfers (2006)). It is based on the idea of winning the match by more than defined number of goals, otherwise is the bet loosing. Because betting belongs to the biggest sources of match rigging I consider the missing data for substitutes as a shortcoming, which can *underestimate* results. To obtain number for whole team performance I average the marks for eleven players. Similarly to the referees, some data from web-page were missing . However, thanks to the high number of players in one team I am able to get all 8326 observations. Even though missing marks can move the average, they do not follow any pattern and I consider the errors as random.

[9] Sutter and Kocher (2004) report that cross-checking of the editors with a referee official reveals their assessment to be *"impartial and sticking very closely to the rules of the game"*.

[10] For example, whole season 1997 of the second Bundesliga lacks the estimates.

4 Empirical Specification

Figure 1: Reaction of point-collection on different incentives



Having stated in the theoretical model, I expect teams to earn the more points the closer they are to the relevant margin. In the same time I expect this effect to be negligible if teams are at the beginning of the season and have still many opportunities to earn appropriate amount of points by playing regular games. Figure 1 depicts the relationship graphically.

However, the effect can be caused either by a cheating or by a change in teams' motivation. To isolate the effects I run regressions on (1) referee's performance and (2) players' performance conditional on different teams' incentives.

To get estimates for whole season I regress equation 20. Due to the unclear significance of Intertoto cup as a potential margin I estimate both samples – with and without Intertoto cup observations.

$$
\begin{aligned}
Points_{i,m} &= \beta_0 + \beta_1(d_i - d_j) + \beta_2 Round_m + \beta_3 Relegation_i \\
&+ \beta_4(d_i - d_j) \times Round_m + \beta_5(d_i - d_j) \times Relegation_i + \beta_6 Relegation_i \times Round_m \\
&+ \beta_7(d_i - d_j) \times Round_m \times Relegation_i + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (20)
\end{aligned}
$$

where $(d_i - d_j)$ denotes the difference in distances from margins of teams i and j. Variable *round* denotes the round at which teams play the match. *Relegation* is a dummy variable with value 1 if team i fights on relegation margin and 0 if for other. $\Theta_{i,j,m}$ stands for all additional control variables such as difference in teams' quality, number of spectators or referee's and players' performance. Λ_i are fixed effects of individual teams and Φ_m covers match-specific fixed effects such as year, month and day in a week.[11]

I expect $(d_i - d_j)$ to *negatively* influence amount of earned points in one round. Concept of distance stands on probability to reach margin. The further is the margin the lower is the probability to reach it. Therefore, team exerts more effort to get points if the distance is smaller. On the other hand, team i is in easier position if team j has high distance. Team i should therefore earn more points with *decreasing* difference in distances, i.e. increasing incentive.

For all three coefficients explaining the effect I expect significant *negative* sign, especially for the latter two. The negative effect of difference on incentives should be even higher with increasing rounds and higher if team fights for survival in a league.

Regression results with three interactions are, however, hard to interpret. To reduce the estimates to only two dimensions I construct regressions on sub-samples of (1) rounds 1 – 10 and (2) rounds 25 – 34. For sub-sample estimation I omit seasons with Intertoto cup to come with clearer estimates. Equation 21 describes the regression:

[11]Fixed effects of referees appear to be insignificant in any kind of specification. On the other hand, the amount of present referees causes over-specification thanks to which I omit referees fixed effects from further estimation.

$$Points_{i,m} = \beta_0 + \beta_1(d_i - d_j) + \beta_2 Relegation_i + \beta_3(d_i - d_j) \times Relegation_i + \Theta_{i,j,m} + \Phi_i + \epsilon \quad (21)$$

I expect first 10 rounds to have smaller effect than the last 10 ones as there is lower amount of future opportunities to earn points and teams are more certain about their final outcome. Similarly to the whole-season estimates I expect the effect to be stronger for teams fighting on relegation margin than for the others.

To better isolate the effect I create a sub-sample dataset based on *rounds* and *home-away stadium* criterion. I expect any effect raised from distance incentives to be higher when team plays at home stadium. Home matches create better opportunity to rig a match as, for example, spectators are in favor of the rigging (winning) team. As Pollard (1986) writes, most of the wins are obtained by a home team. Author reports also reasons ranging from crowd support to familiarity of environment. Similarly, Sutter and Kocher (2004) report on Bundesliga's data referee's bias for home team if it is a goal back.

In all specifications I control for several other variables such as number of spectators, home environment or league. The more spectators visit the match, the higher effort will both teams exert omitting the incentives raised by margin distance. Exerting the best performance, quality of the teams cancels out. I assume normal distribution of teams' quality, which results in relatively small differences for most of the teams resulting in high probability of a draw. Because of the non-linearity of granted points for a win, this would mean decreasing amount of points earned in one round with increasing number of spectators. On the other hand, home environment forces domestic teams to exert better performance, which leads to more earned points. For better understanding of the effect I add also interaction of variables *Home* and *Spectators*. I expect the variable to *positively* influence the amount of earned points by home team as spectators push them forward. However, they also create significant pressure on the players, which can cause them to fail in critical situations (Baumeister and Showers, 1986). Building on study of Zajonc and Sales (1966) I consider the first effect as stronger. Authors experimentally show that audience improves well-learned tasks and worsens rarely-done ones. Regular season includes at least 34 matches in a league plus several cup matches. Furthermore, the tasks are practiced on the training sessions. Therefore, I consider match as a players' regular task, which should improve their performance with higher number of spectators.

Home team variable explains the effects of home environment other than spectators. For example, Pollard (1986) shows that factors like environment familiarity can be more important than a crowd support. I expect the home environment to *positively* influence the amount of earned points in one round.

To control for importance of individual margins I add dummy variables *Champions league*, *European league* and *Relegation margin* for both teams. The effect of every variable is measured comparing it to the case when team competes for a title or an advance to a higher league. I expect positive effects for European competitions as they come up with great amount of financial reward, especially the Champions league. I expect relegation margin to play role especially in the latter stages of a season and average effect to be rather insignificant.

Non-surprisingly, I assume the performance of team i to be on average positively associated with i's point earnings. More complicated situation arises with performance of team j's players. First possibility is that players i react *negatively* on performance of team j. For example, amazing performance of Bayern Munich causes even the best teams to play an inferior role. Opponent's reaction can be, however, also the opposite when good performance of one team requires the other team to *increase* its effort and play above average.

4.1 Is cheating the causality of shifted point earnings?

Better end-season results of survivor teams can be caused both by an increased effort and by a cheating. In the following sections I design equations which help me to shift the causality either to an increased effort or cheating.

Referees should not shift their performance during a season. If their performance reacts on changed incentives of teams I fail to reject the hypothesis of their involvement in cheating.

In case of an increased effort I expect players of a treated team to support the point bonus by a higher effort. Similarly, stable or increased performance of opponent teams with long distance to a closer margin supports rather increased effort explanation. On the other hand, I interpret the causality as cheating if (1) survivor teams do not support their increased point earnings by an increased effort and (2) if an opponent team from the middle of a standings table reacts on the incentive with lower performance. In addition I use variance of players' performance as a proxy for their cooperation. Eleven players are costly to cooperate. In case of cheating I expect the variance of their performance to increase in incentive situation.

4.1.1 Different conditional performance of referees

Referees play an important role in every match, judging often cutting-edge situations. Due to the weak role of modern technologies in a decision making, referees have to build on their own capabilities and subjective judgment. If referees are participating on a match-rigging, I expect their performance to significantly decrease in matches with relatively high incentives of one or the other team. I isolate the effect by running following equation:

$$
\begin{aligned}
Referee's\ mark_m = \beta_0 + \beta_1|d_i - d_j| + \beta_2 Round_m + \beta_3 Relegation_i \\
+ \beta_4 Relegation_j + \beta_5|d_i - d_j| \times Round_m + \beta_6|d_i - d_j| \times Relegation_i \\
+ \beta_7|d_i - d_j| \times Relegation_j + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (22)
\end{aligned}
$$

where $Referee's\ mark_m$ denotes evaluation of referee's performance at match m. In contrast to previous regressions, referee is the same for both teams in a match and therefore it does not matter which team plays on margin. To take the fact into account I take absolute value instead of a simple difference. Other variables are similar to those explained in equation

20 including fixed effects of teams and date fixed effects.[12]

Even though I do not use more than two interactions in referee-bias estimation, I construct sub-sample also for referees. Using first and last 10 rounds I am able to better zoom into the effect by interacting the incentive variable with appropriate margins for both teams. Following the theoretical model, best teams have no systematic incentive to rig the match as they would beat the others anyway. Therefore, I am more interested in estimating the effect for teams competing for survival in the league. The relationship is covered by equation 23.

$$\begin{aligned} Referee's\ mark_m = \beta_0 + \beta_1|d_i - d_j| + \beta_2 Round_m + \beta_3 Relegation_i \\ + \beta_4 Relegation_j + \beta_5|d_i - d_j| \times Relegation_i + \beta_6|d_i - d_j| \times Relegation_j \\ + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (23) \end{aligned}$$

I clear the incentive effects by adding several control variables. Number of spectators can have various effects on referee's performance. More spectators (and therefore higher attention) serve as a check that referee will judge situations correctly. In addition to that, I expect better referees to be assigned to more important matches. For example, to finale of the Champions League are assigned only currently best performing referees. For the last 10 years were 4 referees judging Champions League finale also awarded as the best referee in the world. Others were performing in the top ten (IFFHS, 2014). On the other hand, more spectators creates a pressure on referee causing the performance to go down. The latter effect is, however, applicable especially for less experienced referees assigned to less important matches with less spectators.[13] For *sold-out* matches I expect referee to have better marks especially due to the selection. As I point out above, for matches with

[12] Similarly to point-bias estimates I do not include referees fixed effect due to their insignificance and over-specification.

[13] I run a separate equation to test the argument. Added square of spectators variable proves to be significant for whole-season estimates and for last 10 rounds of the season. In both cases form the estimates concave relationship. The worst marks are estimated for 38,994 spectators and 42,642 respectively.

high importance are selected the best referees who are awarded with better marks.

I model referee's performance also conditional on the margin for which teams compete. Again by selection mechanism I expect referees judging matches of teams playing on European competitions margin to have better marks as teams can be significantly better off after the qualification. Referees who judge teams on relegation margin should have with increasing teams' incentives worse marks in the latter stages of the season if referees participate in match rigging and stable otherwise.

4.1.2 Changing performance of marginal team players

Similarly to referees I estimate the effects of incentives on players' performance. If players are more motivated with increased incentives I expect their marks to be better. On the other hand, if the team can collect more points without increasing players' performance, it raises a question about the mechanism. Following equation estimates the effect:

$$\begin{aligned} Players'\ mark_{i,m} &= \beta_0 + \beta_1(d_i - d_j) + \beta_2 Round_m + \beta_3 Relegation_i \\ &+ \beta_4(d_i - d_j) \times Round_m + \beta_5(d_i - d_j) \times Relegation_i + \beta_6 Relegation_i \times Round_m \\ &+ \beta_7(d_i - d_j) \times Round_m \times Relegation_i + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \end{aligned} \quad (24)$$

where $Players'\ mark_{i,m}$ denotes players' performance of team i. Other estimates follow the ones described in equation 20.

Building on the above-stated I perform sub-sample analysis also for player incentive reaction.[14] Moreover, except of simple sample division on rounds I perform also sampling on home-away environment datasets.

Always two teams play in a match. Shift of the performance of one team might not imply anything if the other team reacts in the same direction. In that case, the effects simply cancel each other out. The performance shift of an opponent team I explore in equation 26. Decreased performance of a team

[14] For the sub-sample estimations I omit season with Intertoto cup.

with long distance to the closest margin if margin team needs it supports the cheating story. On the other hand, increased or stable performance with longer distance would cut the supply of points for teams demanding them.

$$Players'\,mark_{i,m} = \beta_0+\beta_1(d_i-d_j)+\beta_2 Relegation_i+\beta_3(d_i-d_j)\times Relegation_i + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (25)$$

$$Players'\,mark_{j,m} = \beta_0+\beta_1(d_i-d_j)+\beta_2 Relegation_i+\beta_3(d_i-d_j)\times Relegation_i + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (26)$$

I further support the analysis by exploring players' mark variance. Outcome of a football match is not based on a single player, but rather by a cooperation of at least eleven of them. If a team wants to cheat, players have to exert some costs of cooperation. It is probable that optimal amount of players involved in cooperation is less than eleven. These players get lower marks for their performance, while the remaining ones stay rather stable. In other words, the variance of marks in a team increases if the team reacts on a cheating incentive, while remains stable if it does not. Equations 27 and 28 cover the analysis of mark variance.

$$Players'\,mark\,variance_{i,m} = \beta_0+\beta_1(d_i-d_j)+\beta_2 Relegation_i+\beta_3(d_i-d_j) \times Relegation_i + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (27)$$

$$Players'\,mark\,variance_{j,m} = \beta_0+\beta_1(d_i-d_j)+\beta_2 Relegation_i+\beta_3(d_i-d_j) \times Relegation_i + \Theta_{i,j,m} + \Lambda_i + \Phi_m + \epsilon \quad (28)$$

The effect of spectators on players' performance can go both directions. Matches with many spectators are greatly covered also by media, which even strengthens the incentive for players to show-off. Moreover, matches with less spectators signal lower significance of the match, which can cause different selection of players to starting eleven. On the other hand, more spectators create pressure on players, which can cause their performance to decrease. Team consists of eleven players who play many matches per season and are used to the pressure. However, the team is composed such that it always balances various types of players who react differently on pressure.[15] In addition, home environment creates conditions for even stronger influence of spectators on players' performance. Building on the previously-stated I consider similar effects to be applicable on *sold-out* stadium influence on players' performance.

Home team players have better knowledge about the environment and conditions on their own stadium. Moreover, they do not have to travel before the match, which translates into their lower tiredness. Therefore, relaxing the influence of spectators I expect the effect of home stadium to *positively* influence players' performance.

Referee-player quality relationship is potentially endogenous, but I consider the causation going from referee to players as more significant. Players' goal is to play against another team and consider (in ideal circumstances) referee as invisible. On the other hand, referee's goal is to directly interfere in play and judge players' behavior. Moreover, players can influence referee only indirectly, while referee is "dictator" on the pitch, leaving players only very small space for bargaining. Clear judging leaves space for players to play their game, which as a result increases their evaluated performance. Therefore, I expect referee's performance to *positively* imply higher players' performance.

Similarly to previous two cases I expect players to exert *higher* effort when playing for European competitions as they come up with high rewards for participating teams. Relegated team will next season play with less attractive opponents causing the demand for tickets to decrease, which cuts the club's income. Moreover, relegation cuts first Bundesliga's teams from possibility to

[15] I support the story by exploring variance of players' marks. I consider number of spectators as a proxy of match importance. With higher importance increases also pressure on players, which causes them to perform differently. Spectators prove to be one of the few factors influencing variance of players' performance.

play for European cups,[16] which subsequently cuts expected revenues even more. On the other hand, teams competing for survival in a league have only a small chance to compete for the European cups. In contrast, teams winning a title or progressing to higher league earned significant amount of money and respect. Therefore, I expect the relegation margin alone to be *insignificantly different* from the title/advance one.

5 Empirical estimates and discussion

Table 2 present results of whole-season regressions. The table is divided into two main parts. Left part describes results without Intertoto seasons and the right one shows the results with them. I estimate both of them as Intertoto cup plays unclear role in team's decision-making. For each part of the table I estimate equations 20, 22 and equation 24.

Columns (1) and (4) show the results for point-earning reaction on different incentives. Estimation of 3-way interaction involves except the base variables also need to use 4 other interaction variables. Excluding variables presented in the table I add also fixed effect of individual teams and date fixed effect to the regressions. Fixed effects of referees prove to be insignificant for any specification.

Results for incentive-reaction are not conclusive. Even though estimates in both specifications have the predicted sign, crucial three-interaction coefficient does *not* prove to be significant. Predicted signs have also basic distance coefficient and its interaction with round variable. Positive coefficient of the basic difference in distances $(d_i - d_j)$ and negative one of its round interaction suggest raising importance of the margin closeness with approaching end of season. The fact is only slightly strengthened by another two insignificant variables – distance interaction with the relegation margin and three-way interaction term. The first one is positive for both versions,

[16]Team still can qualify to European league through winning German national cup DFB-Pokal. The competition is, however, designed on play-off basis and stands usually on two matches – one at home stadium and away the another. Random influences are therefore quite more visible and one can count on team's quality only from a small part.

Table 2: Regression results for whole season (part 1/2)

	Excluded matches of Intertoto seasons			**Included matches of Intertoto seasons**		
	(1)	(2)	(3)	(4)	(5)	(6)
	Points	Referee's mark	Players' mark	Points	Referee's mark	Players' mark
$Distance_i - distance_j$	0.0159		0.00506	0.0149*		0.00724***
	(1.56)		(1.50)	(1.73)		(2.59)
$(Distance_i - distance_j) \times Round$	-0.000684*		-0.0000276	-0.000679**		-0.000148
	(-1.73)		(-0.22)	(-2.01)		(-1.38)
$(Dist_i - dist_j) \times Relegation_i$	0.00164		-0.0103*	0.00372		-0.0144***
	(0.13)		(-1.74)	(0.35)		(-2.86)
$Round \times Relegation_i$	0.00314**		0.0000226	0.00274**		-0.0000757
	(2.36)		(0.03)	(2.54)		(-0.12)
$(Dist_i - dist_j) \times Round \times Rel_i$	-0.000345		0.000191	-0.000365		0.000390**
	(-0.72)		(0.87)	(-0.89)		(2.04)
$\lvert Distance_i - distance_j \rvert$		0.0247			0.0125	
		(1.47)			(0.86)	
$\lvert Distance_i - distance_j \rvert \times Round$		-0.000919			-0.000398	
		(-1.49)			(-0.74)	
$\lvert Distance_i - distance_j \rvert \times Rel_i$		-0.000812			0.000470	
		(-0.12)			(0.08)	
$\lvert Distance_i - distance_j \rvert \times Rel_j$		-0.00168			0.0000475	
		(-0.25)			(0.01)	
$Relegation\ margin_i$	-0.0338	-0.0265	0.161***	-0.0338	-0.0479**	0.179***
	(-1.14)	(-1.02)	(11.06)	(-1.35)	(-2.11)	(14.99)
$Relegation\ margin_j$	0.0216	-0.0236	0.125***	0.0336*	-0.0418*	0.140***
	(0.96)	(-0.93)	(14.56)	(1.66)	(-1.89)	(18.15)
$Points_{i,t-1} - points_{j,t-1}$	0.00637***	-0.000289	-0.000741*	0.00585***	-0.000215	-0.000670**
	(4.53)	(-0.71)	(-1.92)	(5.06)	(-0.67)	(-2.10)
$Player's\ mark_i$	-0.996***			-0.979***		
	(-82.75)			(-103.45)		
$Player's\ mark_j$	1.027***		-0.610***	1.010***		-0.626***
	(88.61)		(-76.77)	(110.30)		(-99.07)
$Referee's\ mark$	-0.0158***		0.00970**	-0.0151***		0.00302
	(-5.65)		(2.38)	(-7.03)		(0.93)

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
t statistics in parentheses

Table 2: Regression results for whole season (part 2/2)

	Excluded matches of Intertoto seasons			**Included matches of Intertoto seasons**		
	(1)	(2)	(3)	(4)	(5)	(6)
	Points	Referee's mark	Players' mark	Points	Referee's mark	Players' mark
Champions league margin$_i$	-0.00474	0.0344	-0.0602***	-0.00839	0.0457	-0.00384
	(-0.10)	(0.53)	(-2.71)	(-0.30)	(1.28)	(-0.30)
Champions league margin$_j$	0.0605	0.0298	-0.0745***	0.00795	0.0627*	-0.0364***
	(1.30)	(0.48)	(-3.27)	(0.30)	(1.81)	(-2.90)
European league margin$_i$	0.0329	0.00154	0.0538***	-0.0185	-0.0200	0.0768***
	(0.86)	(0.03)	(3.14)	(-0.81)	(-0.72)	(7.33)
European league margin$_j$	-0.00853	0.0180	-0.00165	0.0370*	-0.00650	0.0239**
	(-0.23)	(0.38)	(-0.10)	(1.70)	(-0.24)	(2.37)
Home team	0.288***		-0.0588***	0.273***		-0.0574***
	(10.66)		(-9.30)	(11.15)		(-10.29)
Round	-0.000712	-0.00189	0.000473	0.000217	-0.00915	-0.000525
	(-0.38)	(-0.24)	(0.17)	(0.14)	(-1.39)	(-0.23)
2. Bundesliga	0.205***	0.122	-0.226***	0.158***	0.0177	-0.201***
	(7.84)	(1.57)	(-9.19)	(9.89)	(0.39)	(-12.91)
3. Bundesliga	0.287***	0.0200	-0.629***	0.235***	-0.0493	-0.613***
	(8.28)	(0.24)	(-21.65)	(8.43)	(-0.79)	(-27.04)
Spectators (tsd.)	-0.00180***	0.00159	0.000693	-0.00278***	-0.000422	-0.000303
	(-2.72)	(1.16)	(1.52)	(-6.03)	(-0.46)	(-1.02)
Sold-out	-0.0248*	-0.0799*	-0.0623***	-0.0252***	0.00899	-0.0926***
	(-1.92)	(-1.67)	(-4.19)	(-3.13)	(0.29)	(-9.29)
Spectators $\times$ home (tsd.)	-0.00370***		-0.000619**	-0.00148*		-0.000511**
	(-3.37)		(-2.06)	(-1.83)		(-2.52)
Constant	0.717***	2.566***	5.637***	0.770***	3.282***	5.950***
	(4.00)	(7.47)	(36.61)	(4.39)	(9.27)	(40.84)
N	14804	14804	14804	22762	22762	22762
F	114.9	3.340	89.38	168.8	4.006	137.9
R^2	0.612	0.0308	0.461	0.618	0.0275	0.471

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. The table shows results for both seasons with and without Intertoto cup as there exists trade-off between more observations and higher "distance" precision. Comparing to non-Intertoto seasons I add seasons 1995 – 2007 of first Bundesliga into dataset. In all regressions I include also fixed effects of 85 teams, all years, months and days in a week. Due to the insignificance and to save degrees of freedom I omit fixed effects of referees. In addition to information shown in the table, several facts arise from fixed effects usage. Interestingly, 38 team effects are significant at p ¡ 0.01 in referee-bias estimation. The significance is even underlined by the fact that fixed effects for individual referees are insignificant for almost all referees. Similar or even lower team-effects I find for point and player estimation.

while the opposite proves to be true for the latter one. Looking on the above-stated, one can see the crucial role which plays *round* variable. Except of its interactions are all distance interactions positive.

For example, the effect of distances' difference on team competing for the relegation margin at 10^{th} round is *positive*.[17] If team i is one point closer to the margin than its rival (the term is negative), team i gets 0.00725 *less* points. Modeling the same situation in 30^{th} round, team i earns 0.0133 points *more*. Holding the signs, the effect for non-relegation team shifts to 0.00906 points in the first case and 0.00462 in the latter one. Despite insignificance, results suggest justness of the main hypothesis proved later in the sub-sample analysis.

Digging deeper into the causality of the effect I run an estimation of distance-incentive impact on referee's mark. The results prove not only *insignificant*, but also the signs are opposite to those suggesting referees' involvement in match-rigging. Difference in distances $|d_i - d_j|$ alone is the only positive distance coefficient, i.e. the more different incentives teams have, the *worse* performance referee shows. However, all other coefficients which aim on suspicious situations suggest negative relationship – the higher teams' incentives, the *better* is referee's performance. The only fact suggesting suspicious behavior of referees are the fixed effects (not shown in the table). Interestingly, I fail to prove referee's fixed effects significant for any specification including referee's mark estimation. In contrast to the insignificance, teams' fixed effects are significant and resistant to change in specification. In other words, referees' performance is better distinguishable between teams they judge than between referees themselves.

The most inconsistent results between the specifications with and without Intertoto seasons are for player's mark estimation. Non-Intertoto distance coefficients are mostly insignificant, while the opposite holds for the others. However, signs prove to be consistent between the specifications. Basic difference-in-distances coefficient $(d_i - d_j)$ is *positive* in both cases, although significant only for Intertoto inclusion. Interactions of the distance with round and relegation-margin variables are *negative*. Round interaction

[17] For the calculation I use non-Intertoto seasons.

proves insignificant in both cases suggesting that margin closeness insignificantly *worsens* players' performance through season. The same holds for relegation margin, however, this time *significant* in both specifications.

Several other interesting results arise from the estimates. The most surprising one uncovers estimation of the spectators effect. In general, higher number of spectators increases the probability of a draw.[18] Possible explanation lies in risk-aversion of teams. High number of spectators implies increased costs of failure. When team wants to win, it has to use more players for offense instead of defense resulting in higher exposure to concede a goal. With higher costs teams will rather play safer bet – a draw.

Individual margins does *not* prove to have significant impact on amount of points earned in one round. On the other hand, players competing for Champions league qualification exert *more* effort in match. In the same time, I find the opposite result for European league. The result suggests the importance of individual margins in order (1) Champions league, (2) Title/advance, (3) European league and on the last place is relegation margin. Moreover, marks are formed in couples for team i and j. Possible explanation lies in publicity of the information. Standings table is publicly available making it possible for everybody to form his own prediction. If team i knows that team j competes for relegation margin and knows about its importance, i knows that j will exert lower effort. Knowing the fact, lower performance of team i is sufficient to get points.

5.1 Results for distance-incentive impact on earned points

Considerable complexity of a three-way interaction estimation makes it hard to isolate the effect. Table 3 present the point-bias results of sub-sample analysis thanks to which I am able to eliminate one variable from interaction. Tables are divided into three main parts showing estimates for both first 10 and last 10 rounds of season. Columns (1) and (2) show the results controlling for team and date fixed effects, columns (3) and (4) show results without

[18] The fact arises from non-linearity of awarded points.

them. Finally, last two columns show the results of incentive term applied on each team separately.

Points earned in one round does *not* seem to react on the difference-in-distances incentive term in the first ten rounds. The fact holds also for its interaction with relegation margin variable. The coefficients are consistent in all specifications represented by columns 1, 3 and 5. The result matches to the prediction that teams at the beginning of a season have more options other than match-rigging to reach margin. Similarly, at the end of a season is basic difference-in-distances variable insignificant in both specifications. However, its sign changes consistently for both specifications being positive for first ten rounds and negative for last ten. In contrast to low t-statistics of distance-interaction variable for the season's beginning is its significance at the end of season. Interestingly, the fact does not hold generally, only when aiming on team competing on relegation margin. The result is consistent for both specifications.

Individual team distance measure proves to be less significant determinant of point earnings in a round. Coefficients at the end of a season have, however, predicted signs. Despite insignificance, the fact suggests point-earning reaction on incentives. Other control variables exhibit similar pattern as for whole-season effect estimation.

Figure 2 depicts the incentive-reaction graphically.[19] The figure is divided into three graphs showing results for (a) first stage of the season, (b) the middle and (c) last ten rounds.[20] For the first ten rounds (graph 2a) is the effect flat around zero with strong reaction on tales. Graph 2b depicts situation for rounds 11 – 24. Even thought is the line rather flat, it slightly slopes around zero. Most visible effect is observable on the last graph, which depicts the end of a season. Slope of the line is visibly steeper than for the previous two graphs. In other words, teams react on distance incentives more

[19] For line estimation I use Epanechnikov kernel. To get rid of artificial symmetry caused by double counting of one match for two teams I randomly select 50% of the sample and use it for estimation.

[20] Third Bundesliga has 38 rounds in one season comparing it to 34 rounds in other two leagues. Therefore, the last graph counts with 14 rounds of third Bundesliga instead of 10.

Table 3: Point-bias estimates for first and last 10 rounds (part 1/2)

	Points earned in one round					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
$Distance_i - distance_j$	0.0137	**-0.00446**	0.0108	**-0.00440**		
	(1.03)	**(-1.05)**	(0.82)	**(-1.08)**		
$(Dist_i - dist_j) \times Rel_i$	-0.00239	**-0.0116****	0.00271	**-0.00958****		
	(-0.15)	**(-2.34)**	(0.18)	**(-2.03)**		
$Distance_i$					0.0153	-0.00571
					(1.09)	(-1.23)
$Distance_i \times Relegation_i$					-0.0118	-0.00652
					(-0.62)	(-1.01)
$Distance_j$					-0.00525	0.00293
					(-0.36)	(0.61)
$Distance_j \times Relegation_i$					-0.0164	0.0126*
					(-0.88)	(1.95)
Referee's mark	-0.0215***	-0.00763	-0.0183***	-0.00978**	-0.0187***	-0.00977**
	(-3.65)	(-1.48)	(-3.82)	(-2.18)	(-3.90)	(-2.17)
$Player's\ mark_i$	-0.970***	-1.022***	-0.973***	-1.013***	-0.972***	-1.013***
	(-42.39)	(-44.65)	(-46.16)	(-47.63)	(-46.13)	(-47.58)
$Player's\ mark_j$	1.017***	1.048***	1.026***	1.054***	1.027***	1.054***
	(46.07)	(48.69)	(51.05)	(51.62)	(51.12)	(51.54)
$Points_{i,t-1} - points_{j,t-1}$	0.00454	0.00839***	0.0121*	0.0101***	0.0120*	0.0101***
	(0.73)	(4.04)	(1.94)	(5.06)	(1.92)	(5.03)
Round	-0.00837*	0.00564	-0.000321	0.00109	-0.000283	0.00101
	(-1.70)	(1.57)	(-0.18)	(0.76)	(-0.13)	(0.70)
Home team	0.350***	0.283***	0.303***	0.254***	0.302***	0.255***
	(6.73)	(5.83)	(5.80)	(5.27)	(5.77)	(5.27)
N	4232	4640	4232	4640	4232	4640
F	.	40.36	219.4	219.8	200.4	198.7
R^2	0.625	0.615	0.606	0.604	0.607	0.604

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

t statistics in parentheses

Table 3: Point-bias estimates for first and last 10 rounds (part 2/2)

	Points earned in one round					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
2. Bundesliga	0.268***	0.107**	0.00298	-0.00191	0.00379	-0.00395
	(5.59)	(2.12)	(0.14)	(-0.08)	(0.18)	(-0.17)
3. Bundesliga	0.343***	0.158**	-0.00543	-0.0115	-0.00463	-0.0131
	(5.36)	(2.41)	(-0.22)	(-0.41)	(-0.19)	(-0.47)
Spectators (tsd.)	-0.00252*	0.000492	0.000977	0.00233**	0.000953	0.00232**
	(-1.95)	(0.42)	(0.86)	(2.20)	(0.84)	(2.20)
Sold-out	-0.0583**	0.0128	0.0201	0.0192	0.0210	0.0186
	(-2.06)	(0.64)	(1.28)	(1.36)	(1.33)	(1.30)
Spectators $\times$ *home (tsd.)*	-0.00530**	-0.00575***	-0.00243	-0.00407**	-0.00241	-0.00407**
	(-2.53)	(-2.87)	(-1.17)	(-2.08)	(-1.16)	(-2.08)
$Relegation\ margin_i$	0.0210	0.0595	-0.0194	0.0198	0.0163	-0.00983
	(0.46)	(1.28)	(-0.42)	(0.45)	(0.31)	(-0.16)
$Relegation\ margin_j$	0.0309	-0.0236	0.00688	-0.0381	-0.0116	-0.0379
	(0.68)	(-0.53)	(0.15)	(-0.87)	(-0.22)	(-0.87)
$Champions\ league\ margin_i$	0.0759	-0.0492	0.0561	-0.101	0.0618	-0.107
	(0.91)	(-0.48)	(0.66)	(-1.09)	(0.73)	(-1.14)
$Champions\ league\ margin_j$	-0.0311	0.110	-0.0531	0.117	-0.0564	0.116
	(-0.37)	(1.17)	(-0.61)	(1.26)	(-0.65)	(1.25)
$European\ league\ margin_i$	0.0906	0.0716	0.0749	0.0467	0.0778	0.0426
	(1.09)	(0.94)	(0.91)	(0.67)	(0.95)	(0.61)
$European\ league\ margin_j$	-0.0133	-0.0675	-0.0539	-0.0837	-0.0574	-0.0837
	(-0.17)	(-0.95)	(-0.66)	(-1.20)	(-0.70)	(-1.20)
Constant	0.259	1.030***	1.101***	1.111***	1.087***	1.126***
	(0.81)	(3.14)	(12.61)	(11.55)	(12.33)	(11.46)
N	4232	4640	4232	4640	4232	4640
F	.	40.36	219.4	219.8	200.4	198.7
R^2	0.625	0.615	0.606	0.604	0.607	0.604

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimations (1) and (2) include also fixed effects of 85 teams, all years, months and days in a week. For regressions (1) – (4) I use difference of distances to measure the closeness to the margin. On the other hand, in regressions (5) and (6) I use individual distances of both teams.

with approaching end of a season. The reaction is consistent with expectation – teams relatively closer to the margin earn *more* points in a round while the opposite is true for teams in distance.

In every graph is average pattern different from the one on tales. I consider the fact as a result of margin creation. I create sharp borders between the margins for which teams play and its subsequent distance to it. In reality are the margins less strict, e.g. team closer to the Champions league margin can still have an ambition to win a title (and qualify for Champions league).

5.1.1 Results for home-away environment

Table 4 shows the results of environment-specific estimates. None of the distance estimates proves to be significant and distinguishable between the home and away environment. Although the coefficients have predicted sign, the division of data weakens the effect.

Intriguing situation arises when looking on the relegation margin variable coefficients. Team competing for survival in a league earns at the end of season significantly *more* points when playing on home stadium. The effect holds for both team i and the opponent. Relegation-margin team (again solely at the season's end) earns *less* points comparing to title/advance margin.

Running separate regressions for home and away environment I am able to clearly isolate the effect of spectators. Number of people watching a match has significantly *positive* impact on amount of earned points for home team. Conversely, the effect is *negative* for away team. Interestingly, the effect of sold-out stadium is *negative* for home team and *positive* for away one. In addition to that is the effect applicable only to the beginning of season. Other control variables follow the estimates from previous regressions and only a few differences can be found between the home and away sample.

5.2 Referees (non)reaction on teams' incentives

Insignificant results for distance-incentive variable as a determinant of referee's performance suggest their non-involvement in match-rigging. Table 5 shows the results of the sub-sample referee analysis. I estimate the effects

Table 4: Results for point-bias effect divided by home-away environment

	Points at home		Points away	
	Rnds. 1-10	Rnds. 25-34	Rnds. 1-10	Rnds. 25-34
$Distance_i - distance_j$	0.0227	-0.00467	0.00673	-0.00509
	(1.41)	(-0.99)	(0.45)	(-1.04)
$(Dist_i - dist_j) \times Rel_i$	-0.0129	-0.0103	0.0120	-0.00709
	(-0.57)	(-1.54)	(0.56)	(-1.08)
Round	0.000807	-0.0125**	-0.00104	0.0150***
	(0.12)	(-2.27)	(-0.17)	(2.90)
$Points_{i,t-1} - points_{j,t-1}$	0.0138**	0.00921***	0.00845	0.00866***
	(2.07)	(4.41)	(1.33)	(4.19)
Spectators (tsd.)	0.00458**	0.00371**	-0.00534***	-0.00365**
	(2.56)	(2.13)	(-3.02)	(-2.14)
Sold-out	-0.159**	-0.0241	0.195***	0.0518
	(-2.34)	(-0.43)	(2.94)	(0.93)
Referee's mark	-0.0223	-0.0275	-0.0105	0.00951
	(-1.26)	(-1.59)	(-0.63)	(0.57)
$Player's\ mark_i$	-1.116***	-1.162***	-0.816***	-0.839***
	(-26.18)	(-29.39)	(-17.91)	(-18.84)
$Player's\ mark_j$	0.924***	0.944***	1.121***	1.159***
	(19.66)	(20.80)	(28.03)	(30.80)
$Relegation\ margin_i$	0.0464	0.140***	-0.0882*	-0.123**
	(0.86)	(2.63)	(-1.66)	(-2.36)
$Relegation\ margin_j$	0.0448	0.0976*	-0.0295	-0.161***
	(0.81)	(1.80)	(-0.56)	(-3.10)
$Champ.\ league\ margin_i$	-0.00362	-0.232*	0.113	0.0172
	(-0.03)	(-1.86)	(1.06)	(0.13)
$Champ.\ league\ margin_j$	-0.113	0.0475	-0.000342	0.182
	(-1.02)	(0.35)	(-0.00)	(1.51)
$European\ league\ margin_i$	0.0960	0.0714	0.0704	0.0325
	(0.90)	(0.74)	(0.67)	(0.35)
$European\ league\ margin_j$	-0.0449	-0.0565	-0.0805	-0.141
	(-0.41)	(-0.60)	(-0.80)	(-1.48)
Constant	2.002***	2.398***	0.474	0.0261
N	2116	2320	2116	2320
F	239.9	226.2	200.9	205.7
R^2	0.590	0.596	0.589	0.589

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimates (1) and (2) show the results for solely home teams divided further between matches played in first and last 10 rounds in a season. Similarly, estimates (3) and (4) cover away teams. Except shown estimates I control for the league.

both with and without team and date fixed effects.

The only point at which behavior of referees seems suspicious are again fixed effects of particular teams. In addition to that, team fixed effects prove to be *more* significant for end-of-season estimates. The fact, however does *not* imply match rigging. In the last rounds it is clearer for which margin team competes and what is the probability of reaching it. With rising pressure at the end of season it is even more necessary to judge situations correctly to not raise unnecessary overreaction of players. Committee assigning referees to particular matches identifies potentially dangerous matches and assigns a better one to it. The argument is backed by the signs of distance variables. Even though they prove to be insignificant, the signs are consistent for both specifications and for both team i and team j. In the season's first stage have teams competing for relegation *negative* impact on referee's performance with higher closeness. In contrast, at the end of season is the effect *positive*. Similarly, referees' performance is *significantly higher* if they compete for Champions league margin. As I claim above, Champions league is associated with great amount of financial resources ranging from UEFA donations, higher amount of sponsor donations to increase in income from home matches. Likewise, Champions league is associated also with great amount of reputation as, for example, its matches broadcast all over the Europe and world. High rent associated with successful competition qualification incentivizes teams to widen their used "toolbox". As a result, better referees are assigned for the suspicious matches.

To back previous-stated arguments up, figure 3 shows polynomial smoothing of referee's mark on difference of distances. First graph in the figure shows estimates for rounds $1 - 10$. Line does *not* show any reaction on change in incentives and remains flat for whole domain. Graph 3b shows the estimates from the middle of season. Equally to the previous case, the shape of the line is flat lying slightly above mark 3. Insignificance of distance incentives on referee's performance is underlined by the last graph, which is again flat, especially around zero distance difference. Graphs 3b and 3c reveal tales slightly different from average behaviour. The fact can be caused by two reasons; firstly, for extreme incentives exert referees extraordinary performance.

Table 5: Referee-bias estimates for rounds 1-10 and rounds 25-34

	Referee's mark			
	1-10	25-34	1-10	25-34
	(1)	(2)	(3)	(4)
$\lvert Distance_i - distance_j \rvert$	-0.0451	**0.00289**	-0.0502	**0.00349**
	(-1.38)	**(0.22)**	(-1.55)	**(0.27)**
$\lvert Dist_i - dist_j \rvert \times Relegation_i$	0.0519*	**-0.0107**	0.0429	**-0.00857**
	(1.96)	**(-1.07)**	(1.63)	**(-0.87)**
$\lvert Dist_i - dist_j \rvert \times Relegation_j$	0.0441*	-0.00794	0.0429	-0.00857
	(1.66)	(-0.80)	(1.63)	(-0.87)
Spectators (tsd.)	0.00395	0.00137	0.00318	0.000646
	(1.55)	(0.59)	(1.31)	(0.30)
Sold-out	0.00934	-0.231***	-0.0503	-0.233***
	(0.10)	(-2.94)	(-0.58)	(-2.98)
Round	0.0361*	-0.0210	0.0159*	-0.0190***
	(1.81)	(-1.41)	(1.73)	(-2.92)
2. Bundesliga	0.219*	0.0537	0.117	-0.234*
	(1.70)	(0.37)	(1.09)	(-1.89)
3. Bundesliga	0.219	-0.232	0.0740	-0.382***
	(1.46)	(-1.46)	(0.61)	(-2.79)
Relegation margin$_i$	-0.0581	-0.0243	-0.0507	-0.0246
	(-1.32)	(-0.42)	(-1.19)	(-0.46)
Relegation margin$_j$	-0.0467	-0.0222	-0.0507	-0.0246
	(-1.08)	(-0.41)	(-1.19)	(-0.46)
Champions league margin$_i$	0.125	-0.276**	0.148	-0.229**
	(1.16)	(-2.19)	(1.39)	(-2.07)
Champions league margin$_j$	0.118	-0.198*	0.148	-0.229**
	(1.10)	(-1.79)	(1.39)	(-2.07)
European league margin$_i$	-0.0235	-0.123	-0.0116	-0.119
	(-0.26)	(-1.25)	(-0.13)	(-1.28)
European league margin$_j$	-0.0314	-0.0927	-0.0116	-0.119
	(-0.35)	(-0.99)	(-0.13)	(-1.28)
Constant	2.337***	4.617***	2.951***	4.012***
	(4.42)	(9.67)	(21.89)	(16.99)
N	4232	4640	4232	4640
F	.	2.320	.	.
R^2	0.0467	0.0610	0.00585	0.0187

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimations (1) and (2) include also fixed effects of 85 teams, all years, months and days in a week. For all regressions I use absolute value of difference in teams' distances as a measure of referee's exposure to marginal benefits of the teams.

Second reason is rather technical; strict margin do not perfectly correspond to reality. For example, Bayern Munich will always want to compete for a title even though it is few points back. Due to the inconsistent tail movements between graphs 3b and 3c I consider the latter one as stronger.

Altogether, the quality of referee's performance seems to be quiet independent on any determinants. Overall significance of the referee-bias models float on very low levels comparing it to the other two. In conclusion of the above-stated I do *not* expect referees to participate on match rigging.

5.3 Player-bias reaction on distance-incentive

Even though players react on average *positively* on distance incentive, zooming into the relegation margin reveals teams' *no higher* performance at the end of a season. Table 6 presents the results. In contrast to that are results of the opponent teams j, which exert *lower* performance when team i is in the incentive situation. Team players appear to act unitedly as the performance variance does *not* react on the incentives. Whole model of performance variance has small significance implying that players are rather homogeneous.

Looking on the distance variables reveals that players' reaction on the distance to margin is rather *insignificant* for first ten rounds. Simple difference in distances of the teams is weakly positively significant for fixed effects specification, while its significance decreases when the effects are removed. The distance's interaction with relegation margin appears to be negligible, but consistently *negative* for all specifications. The situation is more intriguing when looking at the end of season. Basic difference-in-distances variable reveals *significantly positive* effect on players' performance. In other words, the higher are incentives, the better is the performance of team i's players. The effect is consistent between the specifications. However, the interaction term is significantly *negative* for all specifications. Teams competing for survival in a league show *no change* in performance at the end of a season. The effect is *consistent* through all the specifications.

Negative interaction coefficient is surprising as relegation is the "lowest" margin in terms of points needed to reach it, while the comparable

Table 6: Estimates of players' performance reaction on changing incentives for first and last 10 rounds (part 1/2)

	Mark of a treated team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
$Distance_i - distance_j$	0.00800*	**0.00478*****	0.00681	**0.00443*****		
	(1.79)	**(3.38)**	(1.51)	**(3.23)**		
$(Dist_i - dist_j) \times Rel_i$	-0.0100	**-0.00517****	-0.00516	**-0.00412***		
	(-1.28)	**(-2.25)**	(-0.64)	**(-1.82)**		
$Distance_i$					0.0152**	0.00903***
					(2.31)	(3.99)
$Distance_i \times Rel_i$					-0.00496	-0.00676**
					(-0.48)	(-2.09)
$Distance_j$					0.00297	0.000752
					(0.43)	(0.32)
$Distance_j \times Rel_i$					0.00278	0.000735
					(0.28)	(0.23)
$Player's\ mark_j$	-0.641***	-0.572***	-0.616***	-0.561***	-0.616***	-0.562***
	(-45.83)	(-39.61)	(-41.44)	(-36.62)	(-41.27)	(-36.70)
$Points_{i,t-1} - points_{j,t-1}$	-0.0000292	-0.00126**	-0.00300**	-0.00208***	-0.00307**	-0.00205***
	(-0.02)	(-2.30)	(-2.03)	(-4.32)	(-2.08)	(-4.25)
Round	-0.00788	-0.0146***	-0.000348	-0.00998***	-0.00429	-0.0109***
	(-1.13)	(-2.78)	(-0.12)	(-4.17)	(-1.21)	(-4.50)
2. Bundesliga	-0.234***	-0.278***	-0.164***	-0.275***	-0.171***	-0.277***
	(-5.58)	(-5.97)	(-4.87)	(-6.65)	(-5.04)	(-6.73)
3. Bundesliga	-0.506***	-0.667***	-0.433***	-0.631***	-0.439***	-0.630***
	(-10.03)	(-12.17)	(-10.74)	(-13.22)	(-10.85)	(-13.23)
N	4416	4820	4416	4820	4416	4820
F	.	31.37	153.6	147.6	138.2	133.3
R^2	0.493	0.454	0.431	0.402	0.432	0.404

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

t statistics in parentheses

Table 6: Estimates of players' performance reaction on changing incentives for first and last 10 rounds (part 2/2)

	Mark of a treated team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
Relegation margin$_i$	0.155***	0.170***	0.146***	0.143***	0.149***	0.173***
	(9.65)	(9.79)	(9.29)	(8.97)	(6.99)	(6.26)
Relegation margin$_j$	0.102***	0.145***	0.104***	0.149***	0.104***	0.151***
	(6.46)	(8.82)	(6.58)	(9.34)	(6.56)	(9.44)
Champions league margin$_i$	-0.0163	-0.0792*	-0.0774**	-0.161***	-0.0755*	-0.150***
	(-0.41)	(-1.89)	(-1.99)	(-3.92)	(-1.95)	(-3.65)
Champions league margin$_j$	-0.117***	-0.0520	-0.111***	-0.0472	-0.109***	-0.0427
	(-3.16)	(-1.16)	(-2.92)	(-1.02)	(-2.90)	(-0.92)
European league margin$_i$	0.0295	0.0951***	0.0000869	0.0175	0.00190	0.0199
	(0.90)	(2.74)	(0.00)	(0.50)	(0.06)	(0.57)
European league margin$_j$	-0.00626	-0.00260	-0.0107	-0.00137	-0.00936	-0.00321
	(-0.19)	(-0.08)	(-0.31)	(-0.04)	(-0.28)	(-0.09)
Spectators (tsd.)	0.00130	-0.000399	0.00189**	0.0000741	0.00192**	0.000150
	(1.60)	(-0.52)	(2.40)	(0.10)	(2.44)	(0.20)
Sold-out	-0.0572**	-0.0534**	-0.0766***	-0.0653***	-0.0755***	-0.0591**
	(-2.17)	(-2.20)	(-3.03)	(-2.68)	(-3.00)	(-2.41)
Home team	-0.0706***	-0.0563***	-0.0678***	-0.0603***	-0.0678***	-0.0604***
	(-6.03)	(-4.84)	(-5.83)	(-5.35)	(-5.82)	(-5.37)
Spectators × *home (tsd.)*	0.0000467	-0.00106*	-0.000478	-0.00100*	-0.000479	-0.00100*
	(0.08)	(-1.89)	(-0.86)	(-1.84)	(-0.86)	(-1.84)
Constant	6.014***	6.191***	5.747***	5.980***	5.753***	5.963***
	(38.26)	(28.33)	(84.59)	(59.21)	(83.35)	(58.61)
N	4416	4820	4416	4820	4416	4820
F	.	31.37	153.6	147.6	138.2	133.3
R^2	0.493	0.454	0.431	0.402	0.432	0.404

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimations (1) and (2) include also fixed effects of 85 teams, all years, months and days in a week. For regressions (1) – (4) I use difference of distances to measure the closeness to the margin. On the other hand, in regressions (5) and (6) I use individual distances of both teams.

title/advance margin is the highest. Knowing that in case of not reaching the margin I still can qualify for European cups (in first Bundesliga) or simply remain without exercising any margin. On the other hand, teams competing on relegation margin are fighting for survival with no insurance making marginal costs of lost point higher. In contrast to expected *higher* performance of relegation teams is its estimated *lower* performance at the end of a season. The fact is surprising especially in connection to point-bias estimates. Table 6 shows that in the same time when players exert *lower* performance they earn *more* points.

The results are weaker when looking on players' performance separately for home and away environment. The signs of coefficients in Table 7 are consistent with the previous results. Even though are the coefficients insignificant, t-statistics show raising importance of the incentive term at the end of a season. Importantly, there is *no* difference of players' performance in reaction on incentive term between home and away environment.

Supply for the reported point demand can be created only by an opponent team if it is sufficiently far from the closest margin. Similarly to the previous analysis I explore shift of the opponent team performance in reaction to changed incentives. In case of a present cheating I expect opponent team to *decrease* its performance if it plays against team fighting for a survival margin at the end of a season. Table 7 summarizes the estimates of equation 26. Opponent teams j with a longer distance to the closest margin do not seem to react in every case. The only case in which players react *negatively* on changed incentives is when players of a treated team i compete for a survival in a league. Moreover, the effect is again present solely at the end of a season. In other words, players of an opponent team *decrease* their performance in the moment when treated team needs it on average. Summing it up in connection with previous estimates, players of teams fighting for a survival margin earn too *many* points while exerting *no bigger* effort at the end of a season. In contrast to that, players of an opponent team exert in the same time *lower* performance.

Table 7: Different players' performance for home-away environment

	Players' mark at home		**Players' mark away**	
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
$Distance_i - distance_j$	0.0123	0.00548**	0.00418	0.00313
	(1.48)	(2.42)	(0.54)	(1.37)
$(Dist_i - dist_j) \times Rel_i$	-0.00601	-0.00478	-0.0111	-0.00363
	(-0.51)	(-1.41)	(-0.99)	(-1.13)
$Player's\ mark_j$	-0.651***	-0.618***	-0.609***	-0.527***
	(-36.77)	(-32.44)	(-33.36)	(-31.05)
Referee's mark	0.0267***	0.0117	0.00325	0.000633
	(3.00)	(1.35)	(0.38)	(0.08)
Round	-0.00130	-0.00930***	-0.00125	-0.0107***
	(-0.41)	(-3.28)	(-0.39)	(-4.10)
Spectators (tsd.)	0.000135	-0.00233**	0.00159*	-0.000666
	(0.16)	(-2.53)	(1.79)	(-0.78)
Sold-out	-0.0941***	-0.0973***	-0.0605**	-0.0135
	(-3.20)	(-3.36)	(-1.98)	(-0.47)
$Points_{i,t-1} - points_{j,t-1}$	0.00248	-0.00102	-0.00718**	-0.00307***
	(0.72)	(-0.98)	(-2.19)	(-3.07)
Relegation margin$_i$	0.170***	0.121***	0.133***	0.162***
	(6.36)	(4.56)	(4.93)	(6.46)
Relegation margin$_j$	0.0923***	0.172***	0.117***	0.139***
	(3.37)	(6.36)	(4.46)	(5.64)
Champ. league margin$_i$	-0.0330	-0.104*	-0.113**	-0.194***
	(-0.56)	(-1.82)	(-2.10)	(-3.33)
Champ. league margin$_j$	-0.175***	-0.163**	-0.0462	0.0890
	(-3.26)	(-2.42)	(-0.82)	(1.44)
European league margin$_i$	0.0600	0.0311	-0.0562	0.00718
	(1.28)	(0.62)	(-1.12)	(0.15)
European league margin$_j$	-0.0475	-0.0546	0.0341	0.0668
	(-0.96)	(-1.13)	(0.69)	(1.41)
Constant	5.797***	6.192***	5.709***	5.832***
	(67.17)	(47.54)	(66.30)	(49.62)
N	2116	2320	2116	2320
F	104.0	94.53	86.46	94.06
R^2	0.434	0.396	0.438	0.414

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimates (1) and (2) show the results for solely home teams divided further between matches played in first and last 10 rounds in a season. Similarly, estimates (3) and (4) cover away teams. Except shown estimates I control for the league.

Table 8: Estimates of an opponent team players' performance reaction on changing incentives for first and last 10 rounds (part 1/2)

	Mark of an opponent team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
$Distance_i - distance_j$	-0.000104	**0.00148**	-0.00329	**0.000130**		
	(-0.02)	**(1.00)**	(-0.74)	**(0.09)**		
$(Dist_i - dist_j) \times Rel_i$	-0.00938	**-0.00643*** **	-0.00230	**-0.00470** **		
	(-1.18)	**(-2.76)**	(-0.28)	**(-2.08)**		
$Distance_i$					0.00173	0.00451*
					(0.27)	(1.86)
$Distance_i \times Rel_i$					0.0106	-0.00687**
					(1.15)	(-2.11)
$Distance_j$					0.00873	0.00478**
					(1.25)	(2.01)
$Distance_j \times Rel_i$					0.00920	0.00178
					(0.92)	(0.55)
$Player's\ mark_i$	-0.648***	-0.587***	-0.616***	-0.561***	-0.616***	-0.562***
	(-46.18)	(-39.87)	(-41.43)	(-36.60)	(-41.39)	(-36.69)
$Points_{i,t-1} - points_{j,t-1}$	0.00284*	0.00142**	0.00336**	0.00219***	0.00339**	0.00221***
	(1.89)	(2.57)	(2.25)	(4.51)	(2.27)	(4.55)
Round	-0.00802	-0.0149***	-0.000305	-0.00996***	-0.00404	-0.0109***
	(-1.14)	(-2.80)	(-0.11)	(-4.17)	(-1.14)	(-4.49)
2. Bundesliga	-0.190***	-0.209***	-0.164***	-0.275***	-0.171***	-0.278***
	(-4.45)	(-4.32)	(-4.87)	(-6.66)	(-5.04)	(-6.74)
3. Bundesliga	-0.442***	-0.577***	-0.433***	-0.631***	-0.439***	-0.630***
	(-8.56)	(-10.18)	(-10.75)	(-13.23)	(-10.86)	(-13.24)
N	4416	4820	4416	4820	4416	4820
F	.	27.68	153.7	147.3	138.2	133.6
R^2	0.486	0.439	0.431	0.402	0.432	0.404

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
t statistics in parentheses

Table 8: Estimates of an opponent team players' performance reaction on changing incentives for first and last 10 rounds (part 2/2)

	Mark of an opponent team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
Relegation margin$_i$	0.128***	0.182***	0.106***	0.151***	0.0843***	0.177***
	(8.02)	(10.25)	(6.67)	(9.46)	(4.01)	(6.35)
Relegation margin$_j$	0.152***	0.158***	0.145***	0.141***	0.146***	0.143***
	(9.75)	(9.57)	(9.15)	(8.82)	(9.19)	(8.92)
Champions league margin$_i$	-0.0606	-0.00685	-0.110***	-0.0473	-0.112***	-0.0384
	(-1.56)	(-0.14)	(-2.91)	(-1.02)	(-2.97)	(-0.82)
Champions league margin$_j$	-0.0857**	-0.162***	-0.0780**	-0.160***	-0.0744*	-0.156***
	(-2.23)	(-3.89)	(-2.00)	(-3.93)	(-1.92)	(-3.81)
European league margin$_i$	0.00749	0.0596	-0.0108	-0.00474	-0.0110	-0.00290
	(0.23)	(1.62)	(-0.32)	(-0.14)	(-0.32)	(-0.09)
European league margin$_j$	-0.000960	0.0300	0.000126	0.0206	0.00373	0.0187
	(-0.03)	(0.86)	(0.00)	(0.59)	(0.11)	(0.54)
Spectators (tsd.)	0.000584	-0.00187**	0.00140*	-0.000945	0.00145*	-0.000868
	(0.75)	(-2.31)	(1.87)	(-1.23)	(1.93)	(-1.14)
Sold-out	-0.0845***	-0.0727***	-0.0767***	-0.0652***	-0.0762***	-0.0592**
	(-3.21)	(-2.95)	(-3.04)	(-2.68)	(-3.02)	(-2.41)
Home team	0.0600***	0.0631***	0.0678***	0.0606***	0.0682***	0.0603***
	(5.19)	(5.45)	(5.83)	(5.38)	(5.87)	(5.36)
Spectators $\times$ *home (tsd.)*	0.000527	0.000595	0.000490	0.00103*	0.000482	0.00103*
	(0.97)	(1.01)	(0.88)	(1.89)	(0.87)	(1.88)
Constant	5.846***	6.244***	5.679***	5.918***	5.691***	5.905***
	(36.84)	(26.72)	(81.25)	(57.98)	(80.60)	(57.55)
N	4416	4820	4416	4820	4416	4820
F	.	27.68	153.7	147.3	138.2	133.6
R^2	0.486	0.439	0.431	0.402	0.432	0.404

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimations (1) and (2) include also fixed effects of 85 teams, all years, months and days in a week. For regressions (1) – (4) I use difference of distances to measure the closeness to the margin. On the other hand, in regressions (5) and (6) I use individual distances of both teams.

5.3.1 Unchanged player performance variance in response to incentives

Digging deeper into the cause of an increased point earning of the "survivors" at the end of season I present also estimates of incentive effect on the players performance variance. Table 9 summarizes results of equation 27 estimation. Almost all distance terms are insignificant. The interpretation can be twofold. Firstly, the insignificance leads to the conclusion that team players create united block and do not deviate from the group behavior. I assume non-zero transaction costs, which makes cooperation for cheating harder. No reaction of variance on incentive creates a binary situation when either cheats a whole team or no one. Cooperation of more than 11 players requires substantial costs, which leads to the decrease of cheating. Cheating as the causation of increased point earnings is therefore weakened. Second theory leaves room both for cheating and increased effort causation. Football is a collective game. Performance of one player is hugely dependent also on the performance of his teammates. Therefore, by an externality, it is not necessary to include all players into cheating to worsen the performance of the whole team. In any case, present incentive changes performance of the whole team, not only few individuals. Taking into account all the previous pro-cheating estimates I consider externality explanation as more probable. Moreover, anecdotal evidence from convicted players suggest rather individual involvement in corruption (see e.g. SITA (2013)).

Similarly to the treated team I provide variance analysis also for opponent players. Both treated and opponent teams' variance react *insignificantly* to changed incentives.

Interesting result arises from positive spectators influence on the variance. More spectators cause players to perform differently. Explanation can lie in the higher pressure caused by more spectators.[21] The result suggests that players react diversely on match importance.

[21] I take number of spectators as a proxy of match attractiveness or importance.

Table 9: Estimates of the treated players' performance reaction variance on changing incentives for first and last 10 rounds (part 1/2)

	Mark variance of the treated team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
$Distance_i - distance_j$	0.00219	-0.00140	0.00249	-0.00121		
	(0.70)	(-1.47)	(0.79)	(-1.28)		
$(Dist_i - dist_j) \times Rel_i$	-0.00129	0.000813	-0.00270	0.000994		
	(-0.29)	(0.61)	(-0.61)	(0.74)		
$Distance_i$					0.00366	-0.00283**
					(0.91)	(-2.35)
$Distance_i \times Rel_i$					-0.00442	0.00247
					(-0.81)	(1.44)
$Distance_j$					-0.00107	-0.000612
					(-0.25)	(-0.44)
$Distance_j \times Rel_i$					0.000888	0.000688
					(0.16)	(0.37)
$Player's\ mark_j$	-0.0175**	-0.00603	-0.0173**	-0.00584	-0.00258**	0.000188
	(-2.44)	(-0.97)	(-2.42)	(-0.94)	(-1.98)	(0.51)
$Points_{i,t-1} - points_{j,t-1}$	-0.00306**	-0.000139	-0.00255**	0.000206	-0.00266**	0.000210
	(-2.25)	(-0.35)	(-1.96)	(0.56)	(-2.08)	(0.57)
Round	-0.00534	-0.00150	-0.00110	-0.00280**	-0.00140	-0.00254**
	(-1.52)	(-0.64)	(-0.79)	(-2.57)	(-0.80)	(-2.31)
2. Bundesliga	-0.0369	-0.00409	-0.0617***	-0.0557***	-0.0622***	-0.0555***
	(-1.57)	(-0.17)	(-3.11)	(-2.86)	(-3.10)	(-2.85)
3. Bundesliga	-0.0740***	-0.0866***	-0.118***	-0.109***	-0.118***	-0.109***
	(-2.63)	(-3.23)	(-5.30)	(-4.93)	(-5.28)	(-4.97)
N	4415	4820	4415	4820	4415	4820
F	.	4.567	14.02	16.19	12.79	14.72
R^2	0.112	0.117	0.0597	0.0584	0.0598	0.0592

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

t statistics in parentheses

Table 9: Estimates of the treated players' performance reaction variance on changing incentives for first and last 10 rounds (part 2/2)

	Mark variance of the treated team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
Relegation margin$_i$	-0.0150	-0.00405	-0.0136	-0.00672	-0.00915	-0.0224
	(-1.39)	(-0.40)	(-1.29)	(-0.73)	(-0.70)	(-1.51)
Relegation margin$_j$	0.0177*	0.00405	0.0106	-0.00264	0.0104	-0.00295
	(1.70)	(0.42)	(1.03)	(-0.28)	(1.01)	(-0.31)
Champions league margin$_i$	-0.0120	-0.0283	-0.0166	-0.0107	-0.0158	-0.0151
	(-0.44)	(-0.96)	(-0.64)	(-0.40)	(-0.60)	(-0.56)
Champions league margin$_j$	0.00626	0.00988	0.000577	0.000867	0.000286	-0.000642
	(0.24)	(0.36)	(0.02)	(0.03)	(0.01)	(-0.02)
European league margin$_i$	-0.00589	0.0350	-0.00488	0.0245	-0.00440	0.0228
	(-0.26)	(1.58)	(-0.21)	(1.20)	(-0.19)	(1.12)
European league margin$_j$	-0.000711	-0.0263	-0.0176	-0.0347*	-0.0180	-0.0342*
	(-0.03)	(-1.35)	(-0.77)	(-1.77)	(-0.79)	(-1.75)
Spectators (tsd.)	0.000883*	0.00119***	0.00144***	0.00152***	0.00144***	0.00150***
	(1.67)	(2.73)	(2.91)	(3.62)	(2.91)	(3.58)
Sold-out	0.0204	0.00975	0.0347**	0.0106	0.0349**	0.00869
	(1.22)	(0.74)	(2.18)	(0.82)	(2.19)	(0.67)
Home team	0.0212**	0.0357***	0.0144	0.0278***	0.0143	0.0278***
	(2.22)	(3.86)	(1.52)	(3.09)	(1.51)	(3.10)
Spectators $\times$ *home (tsd.)*	-0.000650	-0.00132***	-0.000268	-0.000876**	-0.000267	-0.000875**
	(-1.41)	(-3.07)	(-0.59)	(-2.10)	(-0.58)	(-2.10)
Constant	0.542***	0.554***	0.567***	0.594***	0.566***	0.603***
	(5.31)	(5.11)	(15.76)	(13.19)	(15.54)	(13.16)
N	4415	4820	4415	4820	4415	4820
F	.	4.567	14.02	16.19	12.79	14.72
R^2	0.112	0.117	0.0597	0.0584	0.0598	0.0592

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: t statistics in parentheses. Estimations (1) and (2) include also fixed effects of 85 teams, all years, months and days in a week. For regressions (1) – (4) I use difference of distances to measure the closeness to the margin. On the other hand, in regressions (5) and (6) I use individual distances of both teams.

Table 10: Estimates of the opponent players' performance reaction variance on changing incentives for first and last 10 rounds (part 1/2)

	Mark variance of the opponent team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
$Distance_i - distance_j$	-0.00222	0.000203	-0.00263	0.000187		
	(-0.71)	(0.23)	(-0.87)	(0.22)		
$(Dist_i - dist_j) \times Rel_i$	0.00436	0.000525	0.00450	0.000572		
	(1.00)	(0.39)	(1.05)	(0.42)		
$Distance_i$					-0.00186	-0.00240**
					(-0.48)	(-2.01)
$Distance_i \times Rel_i$					0.000845	0.00262
					(0.16)	(1.41)
$Distance_j$					0.00366	-0.00308**
					(0.88)	(-2.46)
$Distance_j \times Rel_i$					-0.00783	0.00183
					(-1.45)	(1.06)
$Player's\ mark_i$	-0.0246***	-0.00732	-0.0227***	-0.00501	-0.0228***	-0.00447
	(-3.37)	(-1.13)	(-3.18)	(-0.79)	(-3.20)	(-0.71)
$Points_{i,t-1} - points_{j,t-1}$	0.00245**	-0.000354	0.00220*	-0.000268	0.00217*	-0.000289
	(2.00)	(-0.89)	(1.85)	(-0.74)	(1.82)	(-0.80)
Round	-0.00468	-0.00176	-0.00118	-0.00281**	-0.00102	-0.00236**
	(-1.30)	(-0.71)	(-0.84)	(-2.56)	(-0.57)	(-2.12)
2. Bundesliga	-0.0673***	-0.0321	-0.0586***	-0.0556***	-0.0582***	-0.0548***
	(-2.77)	(-1.32)	(-2.94)	(-2.84)	(-2.89)	(-2.80)
3. Bundesliga	-0.110***	-0.112***	-0.115***	-0.108***	-0.115***	-0.109***
	(-3.78)	(-4.06)	(-5.12)	(-4.89)	(-5.06)	(-4.95)
N	4416	4820	4416	4820	4416	4820
F	.	4.506	13.59	15.49	12.30	14.60
R^2	0.102	0.105	0.0615	0.0589	0.0618	0.0609

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

t statistics in parentheses

Table 10: Estimates of the opponent players' performance reaction variance on changing incentives for first and last 10 rounds (part 2/2)

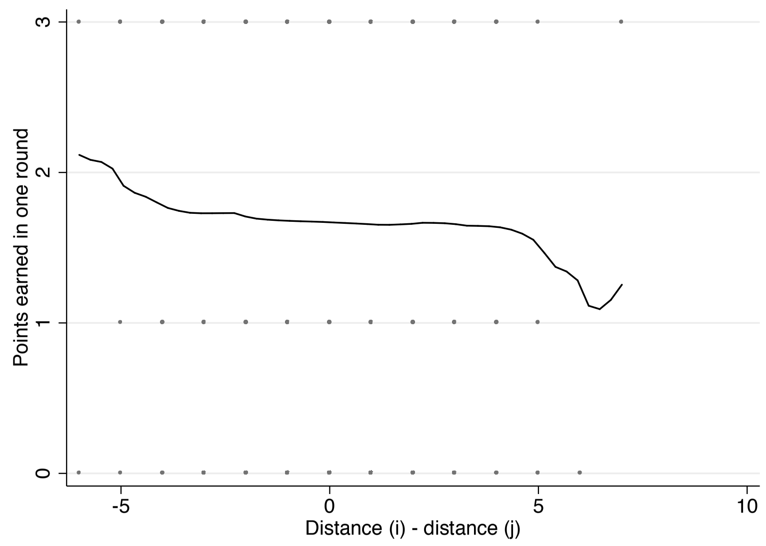
	Mark variance of the opponent team players					
	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34	Rounds 1–10	Rounds 25–34
	(1)	(2)	(3)	(4)	(5)	(6)
Relegation margin$_i$	0.0107	-0.00196	0.0102	-0.00371	0.0190	-0.0259*
	(1.04)	(-0.19)	(1.02)	(-0.40)	(1.45)	(-1.71)
Relegation margin$_j$	-0.00667	-0.00310	-0.00963	-0.00872	-0.0100	-0.00930
	(-0.65)	(-0.33)	(-0.96)	(-0.96)	(-1.00)	(-1.02)
Champions league margin$_i$	0.00681	0.0167	-0.000321	0.000759	0.000955	-0.00564
	(0.25)	(0.55)	(-0.01)	(0.03)	(0.04)	(-0.19)
Champions league margin$_j$	-0.0175	-0.00539	-0.0162	-0.0132	-0.0171	-0.0158
	(-0.66)	(-0.20)	(-0.62)	(-0.50)	(-0.65)	(-0.59)
European league margin$_i$	-0.0186	-0.0290	-0.0181	-0.0346*	-0.0175	-0.0368*
	(-0.82)	(-1.34)	(-0.80)	(-1.76)	(-0.77)	(-1.87)
European league margin$_j$	-0.00219	0.0263	-0.00292	0.0215	-0.00387	0.0225
	(-0.09)	(1.28)	(-0.12)	(1.06)	(-0.16)	(1.10)
Spectators (tsd.)	0.00135**	0.000978**	0.00123**	0.000663	0.00123**	0.000625
	(2.45)	(2.10)	(2.50)	(1.54)	(2.49)	(1.45)
Sold-out	0.0312*	0.0146	0.0353**	0.0102	0.0355**	0.00695
	(1.82)	(1.12)	(2.18)	(0.80)	(2.19)	(0.54)
Home team	-0.0182**	-0.0313***	-0.0169*	-0.0289***	-0.0170*	-0.0287***
	(-1.97)	(-3.53)	(-1.86)	(-3.32)	(-1.87)	(-3.30)
Spectators $\times$ *home (tsd.)*	0.000408	0.00106**	0.000337	0.000938**	0.000340	0.000942**
	(0.88)	(2.50)	(0.75)	(2.27)	(0.75)	(2.27)
Constant	0.732***	0.630***	0.596***	0.621***	0.594***	0.633***
	(6.64)	(6.52)	(16.27)	(13.16)	(16.11)	(13.30)
N	4416	4820	4416	4820	4416	4820
F	.	4.506	13.59	15.49	12.30	14.60
R^2	0.102	0.105	0.0615	0.0589	0.0618	0.0609

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

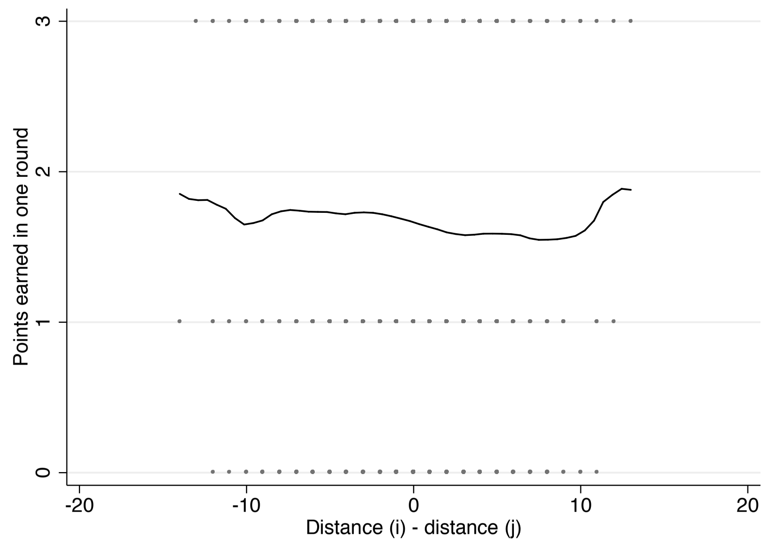
t statistics in parentheses

Figure 2: Amount of earned points conditional on changing incentives
Local polynomial smoothing

(a) Rounds 1 – 10



(b) Rounds 11 – 24



(c) Rounds 25 – 34 (38)

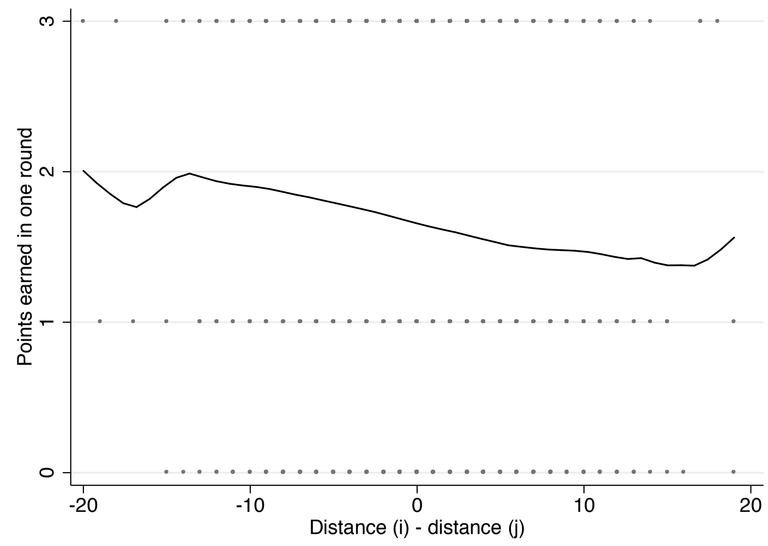
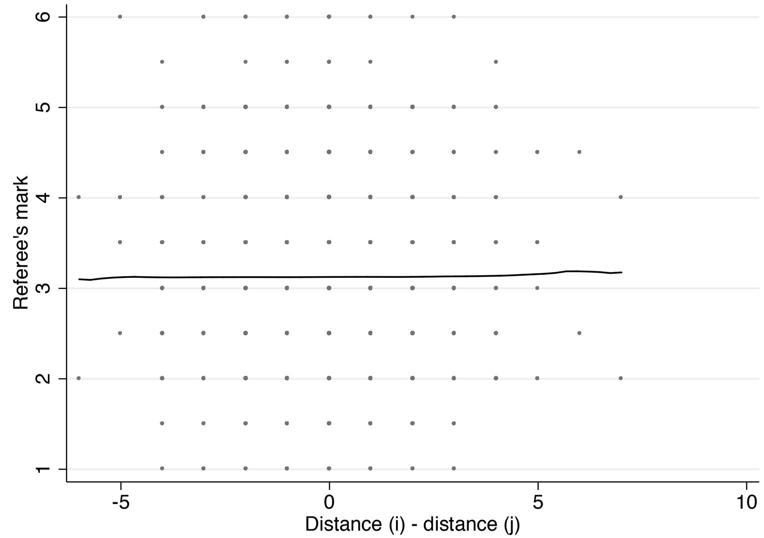
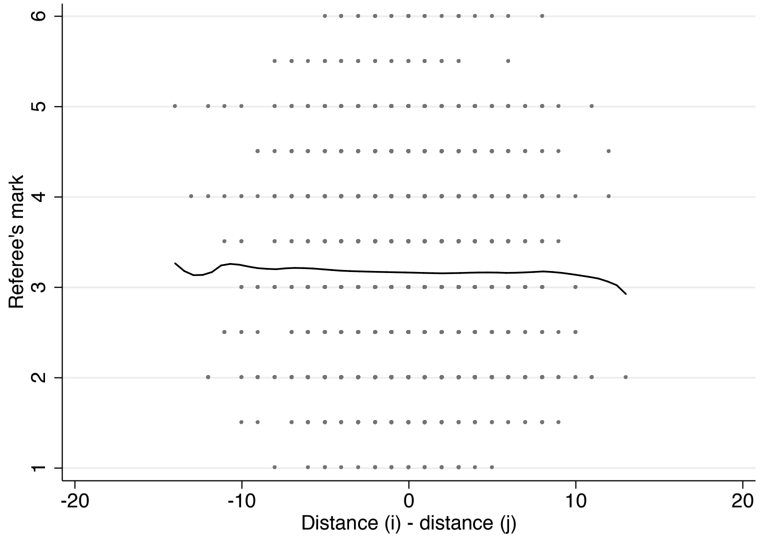


Figure 3: Reaction of referee's performance on changing incentives of teams
Local polynomial smoothing

(a) Rounds 1 – 10



(b) Rounds 11 – 24



(c) Rounds 25 – 34 (38)

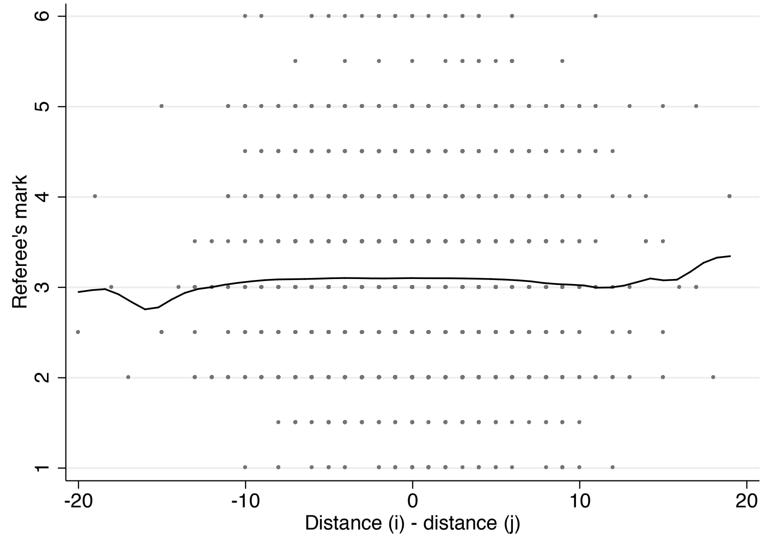
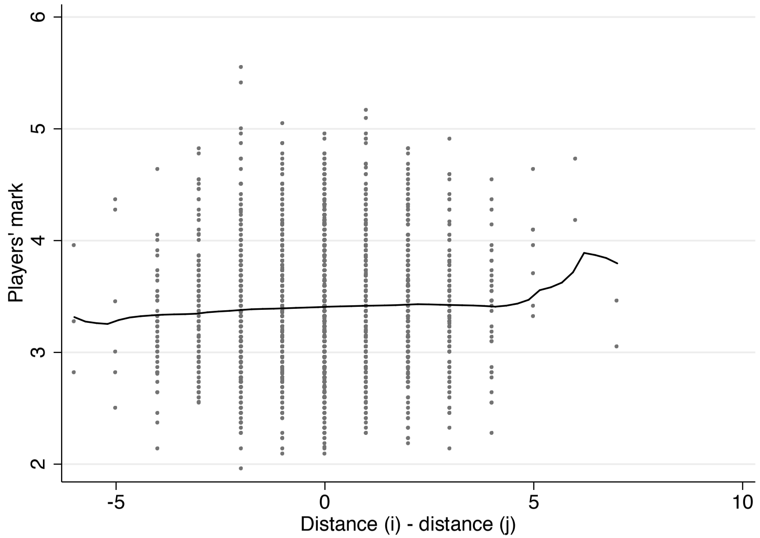
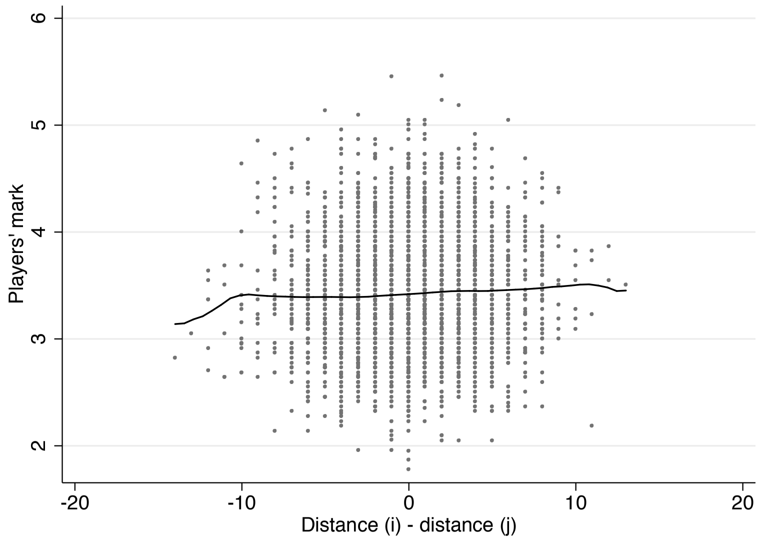


Figure 4: Reaction of players' performance on changing incentives
Local polynomial smoothing

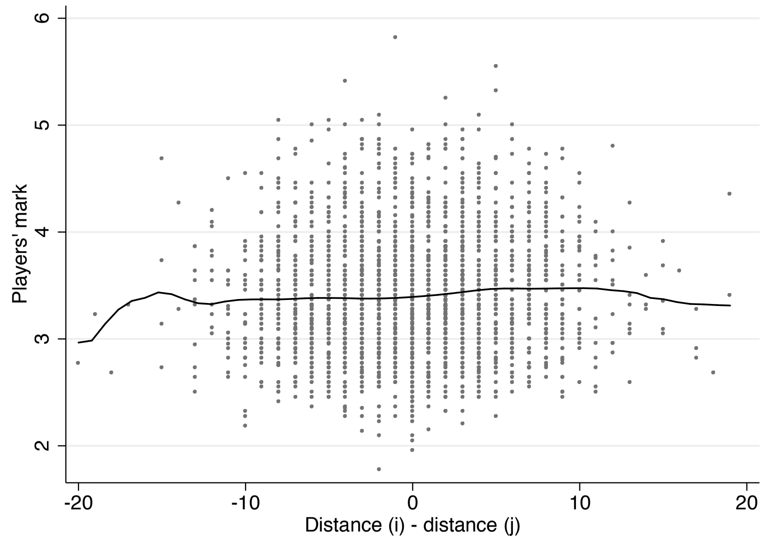
(a) Rounds 1 – 10



(b) Rounds 11 – 24



(c) Rounds 25 – 34 (38)



6 Conclusion

In this thesis I provide statistical analysis of cheating behavior in German long-term football championship Bundesliga. Strong margins and diminishing season's uncertainty provide an incentive structure thanks to which I am able to reveal several patterns. The structure makes cheating-demanders from the teams close to the survival margin and cheating-suppliers from the teams far from all margins. I show that the incentive scheme works for point earnings and players' performance. The bottom teams earn disproportionately more points at the end of a season while exerting no more effort. In contrast, opponent teams who are far from margins exert *less* effort when playing with "survivors". Additionally, I show that referees do not react on teams' changing incentives.

Sport has witnessed many scandals ranging from football (BBC, 2006), Formula 1 (BBC, 2009) or even Olympic games (Hemphill, 2003). In every case were alleged concrete people for being an exception in otherwise good working system. This thesis shows footballers as rationally acting individuals making decisions by weighting revenues and costs of cheating. In this case can system setup make a big difference in level of cheating. The thesis uncovers one of the possible mechanisms through which can cheating occur.

Room for future studies is in using sport statistics instead of a complex subjective performance evaluation. For example, in its simplest form can one use yellow and red cards as an approximation of referee's bias. Moreover, construction of the margins in this thesis rather underestimates the true effect. Stricter differentiation between margins can bring more significant results. Similarly, financial resources gainable after reaching a margin can bring a new perspective to the problem.

The results are interesting especially due to their generalizability. The incentive scheme is applicable to basically every long-term championship based on a point collection, not only on football. In this thesis I explore German environment, which belongs to the least corrupted in the world. The exploration in more corrupted countries can bring more significant results. Considering only football, there are more than 90 football leagues in the world.

Building on the presented thesis, future research can go even beyond that and aim to every long-term championship with an existing lower margin.

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